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HANFORD LABORATORIES OPERATION MONTHLY ACTIVITIES REPORT

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RICHLAND, WASHINGTON

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HANFORD LABORATORIES OPERATION

MONTHLY ACTIVITIES REPORT

AUGUST, 1962

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By Authority of CG-PR-2

RM Iten 8-12-92

TL Phillips 8-21-92

PM Eck 8-26-92

Compiled by

Operation Managers

9/14/62

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RICHLAND, WASHINGTON

PRELIMINARY REPORT

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

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TABLE I - HLO FORCE REPORT

DATE: August 31, 1962

	At Beginning of Month		At Close of Month		Total
	Exempt	Salaried	Exempt	Salaried	
Chemical R & D	142	137	136	138	274
Reactor & Fuels R & D	176	169	178	173	351
Physics & Instrument R & D	97	60	92	60	152
Biology	38	57	39	57	96
Applied Mathematics	19	4	19	4	23
Radiation Protection	42	101	42	97	139
Finance and Administration	119	98	117	95	212
Programming	15	3	15	3	18
General	3	3	3	3	6
Test Reactor & Auxiliaries	52	181	50	186	236
TOTAL	703	813	691	816	1,507

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BUDGETS AND COSTS

August operating costs totaled \$2,236,000, an increase of \$99,000 from the previous month; fiscal year-to-date costs are \$4,373,000 or 15% of the \$28,524,000 tentative control budget. Hanford Laboratories' research and development costs for August, compared with last month and the control budget, are shown below:

(Dollars in thousands)	C O S T				
	<u>Current Month</u>	<u>Previous Month</u>	<u>FY To-Date</u>	<u>Annual Budget</u>	<u>% Spent</u>
HLO Programs					
02 Program	\$ 73	\$ 63	\$ 136	\$ 1 069	13%
03 Program	3	6	9	175	5
04 Program	961	888	1 849	11 150	17
05 Program	98	87	185	1 293	14
06 Program	240	233	473	3 154	15
	<u>1 375</u>	<u>1 277</u>	<u>2 652</u>	<u>16 841</u>	<u>15</u>
FPD Sponsored	88	85	173	1 370	13
IPD Sponsored	94	87	181	1 325	14
CPD Sponsored	<u>150</u>	<u>121</u>	<u>271</u>	<u>1 369</u>	<u>20</u>
Total	<u>\$1 707</u>	<u>\$1 570</u>	<u>\$3 277</u>	<u>\$20 905</u>	<u>16%</u>

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

A section of NPR Zircaloy-2 process tubing has been made into an in-reactor assembly and inserted in the ETR, Idaho Falls, Idaho. This section replaces the stainless steel pressure tube in the P-7 position. The new assembly will operate at NPR conditions of power, flux, and temperature.

A Zircaloy-2-clad uranium rod with intentional striations as deep as 20% of the cladding thickness was irradiated, then subjected to metallographic examination. No concentration of deformation in the striations was observed in spite of a 1.2% total strain of the cladding. This contradicts previous observations of highly localized cladding deformation on irradiation of fuel elements of non-uniform cladding thickness.

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Visual examination of a dual enrichment, single-tube, metallic uranium fuel element after a second cycle of irradiation in the ETR indicated that the element was in excellent condition with no visible indication of damage or corrosion.

A prototypic N fuel element has been charged through a full length N process tube with no scratching of the Zircaloy autoclave film. This test suggests that there is no "length effect" which causes iron clad supports to scratch during charging in full length tubes. It is possible that scratching encountered in earlier experiments was caused by the presence of foreign particles within the tube.

Fabrication of "buggy spring" Zircaloy-2 supports for N fuels from fine grain size strip appears to yield a product less subject to cracking.

Graphite is generally considered impossible to weld; however, recrystallization and bonding was achieved between a graphite cap and a graphite tube by the magnetic force resistance butt welding process.

An impact pressure of 400,000 psi can be obtained in the Dynapack machine with a tungsten carbide punch without resorting to Bridgman anvil techniques. At this pressure micronized UO_2 powder, heated to 1100 C in evacuated cans, can be compacted to 99% T.D. It thus appears feasible to impact large batches (10-14 pounds) directly to high density.

It has been shown that an empty four-inch length of 2.328 inches OD x 0.060-inch wall Zr-2 tubing with end caps welded in place will collapse explosively when subjected to 1100 psi at 400 C. However, the same cladding will not collapse under these conditions when connected by five equally spaced ribs to a 3.068 x 0.060-inch wall Zr-2 outer tube. The latter arrangement allows the fuel tube to resist collapse until a pressure of 1500 psig at 400 C is reached. In addition to acting as a fuel cladding strengthener, the outer tube may possibly be used as a disposable process tube.

Process tube activity records indicate that failure of a swage compacted MgO-PuO_2 19-rod cluster fuel element occurred shortly after the first startup of the PRTR subsequent to charging of this element. Examination of the discharged element is continuing.

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A capsule containing high density UO_2 - 2.57 mole % PuO_2 was discharged from the MTR after an estimated exposure of 10,000 MWD/T and is now undergoing radiometallurgical examination.

Examination of a 42-inch long cosine-enriched UO_2 - PuO_2 seven-rod cluster is in progress following ETR irradiation. Dark spots on the external rod surfaces are definitely associated with regions of high PuO_2 concentration and correspondingly high surface heat fluxes.

Eight Zircaloy-clad capsules containing ZrO_2 - PuO_2 fuel pellets and eight containing MgO - PuO_2 pellets have completed their irradiation in the ETR. Transverse sections of the MgO - PuO_2 samples show that general cracking has occurred in the specimens which operated at maximum core temperatures of 1700 C, whereas center voids and columnar grains have formed in the samples which operated at core temperatures of 2200 C.

Electrical resistivity measurements have been made on samples of plutonium oxides having O/Pu atomic ratios of 1.84, 1.92, and 1.96, and exhibit an electronic activation energy of 0.50 ± 0.02 ev for the single face-centered cubic phase existing above the temperature limit for the solid immiscibility region.

Based on resistivity, thermal expansion, X-ray diffraction, and thermal emf experiments, a phase diagram has been constructed for the Pu-O system.

PuO_2 compatibility tests at 1700 C in a helium atmosphere showed very slight reaction with molybdenum, some observable reaction with tungsten, and apparently complete reaction with tantalum.

Samples of PuC with 5% Pu_2C_3 , and beta Pu_2O_3 have been prepared by the reaction of carbon with PuO_2 at 1800 C in a helium atmosphere. The melting point of beta Pu_2O_3 was observed to be about 2090 C.

Resistivity measurements on a 38 a/o C-Pu alloy gave 230 ohm-cm at room temperature with a slightly positive temperature coefficient.

The average coefficient of linear thermal expansion for plutonium nitride as determined by a high-vacuum, high-temperature X-ray diffractometer attachment was calculated to be $13.80 \times 10^{-6}/^\circ\text{C}$ in the

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range 26-800 C. The average diamond pyramid hardness number for PuN was computed, from the best indentations, to be 370 kg mm^{-2} .

Two coextruded, Zircaloy-clad fuel elements with unwelded titanium bonded end closures failed after 31 days of exposure to 400 C steam. Though no failures have occurred after 38 days in 360 C water, up to 27 mils penetration of the 120-mil bond layer was measured.

The first test in H-1 Loop of the in-reactor corrosion of aluminum was completed during the month. The samples were designed to test corrosion with low and with high beta flux.

Unexpected difficulty was encountered in decontaminating some PRTR primary system piping specimens. The standard APACE procedure was ineffective but did modify the films so that they could be removed by scrubbing. The alkaline permanganate-oxalic acid procedure removed the film and activity, provided high solution velocity obtained. The occurrence points up the need for additional information concerning the characteristics of films formed in pressurized water systems.

Laboratory tests were successful in demonstrating automatic in-line devices for oxygen and ammonia analyses. Continuous hydrazine analyses were obtained during a recent test run in KER-3 Loop. The hydrazine proved effective in controlling the oxygen content of the coolant during the outage.

The Mark III unit for in-reactor monitoring of PRTR pressure tubes is 85% complete.

Metallographic examination of the 24-mil deep corrosion mark in PRTR process tube 5540 caused by contact with the lower fuel element end bracket showed no indication of increased hydrogen content in the metal just beneath the mark.

The pressure drop-flow data obtained recently under PRTR shutdown flow conditions indicate that single phase natural circulation cooling may be inadequate during total power outage. Cooling by light water injection during a total power outage is not certain since the time required to depressurize from operating pressure to the 100 psi light water supply pressure is calculated to be about 15 minutes.

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A re-examination of the thermal hydraulic test data for the PRTR indicates that the allowable tube power can be increased from 1200 KW to 1800 KW if the inlet temperature is decreased sufficiently to prevent bulk boiling at the tube outlet. It was also concluded that the maximum heat flux could be increased from 400,000 to about 750,000 Btu/hr-sq ft without violating the 1.85 boiling burnout safety factor proposed for the PRTR.

The use of the special tools and equipment for discharging ruptured fuel elements from the PRTR Rupture Loop was successfully demonstrated.

Boiling burnout data obtained by General Electric Company at APED with a 1/2-inch OD externally cooled rod and compared with data obtained at Hanford with a 0.444-inch ID internally cooled tube were found to agree very well at high flow rates.

Visual studies performed with an electrically heated test section in a glass tube revealed that very little boiling was induced by any of the devices used to center fuel elements in Hanford production reactor process tubes when the test section was centered coaxially within the tube.

Specimens of zirconium - 2Nb - 2 Sn alloy have been tested in tension after irradiation in the ETR at ambient coolant temperatures. This alloy, irradiated in a number of heat treated conditions, had a considerably higher strength before and after the irradiation than is normal for Zr-2. It is noteworthy that the uniform elongation of this higher strength alloy is superior to that of Zr-2 after an irradiation of approximately 10^{20} nvt.

Specimens of beta-quenched and as-extruded uranium have been irradiated simultaneously to an estimated burnup of 0.16 a/o at a control temperature of 625 C. Macro examination has shown slight warpage in the as-extruded specimen and surface roughening as well as warping in the beta-quenched specimen; some swelling has also occurred. These observations point out that "dimensional instability" still persists above 400 C and possibly as high as 600 C.

Molybdenum single crystals, one-eighth-inch diameter x 15 inches, have been successfully grown by an electron beam floating zone technique. It is expected that seeding of crystals to yield crystals with specific rod axis orientation will now be possible.

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Oxidation specimens of nickel-base alloy R-27 were tested in flowing CO₂ for 300 hours at temperatures of 1700 F and 1800 F. Results of these tests show that the alloy has an oxidation resistance comparable to the austenitic stainless steels under these conditions. Tensile tests indicate that the alloy has considerably more high temperature strength. Specimens are presently being prepared for irradiation to exposures of 10²¹ nvt fast neutrons in a gaseous environment.

2. Physics and Instruments

Instrumentation activities in support of the NPR project included: review of tests on the prototype gamma spectrometer for the fuel failure monitor; recommendations for purchase specifications for the multichannel analyzer to be used with the fuel failure monitor; development of a method for analyzing the dynamic response of start-up instruments; recommendations of tests for the nuclear instrument channels; and review of test procedures for the flow and temperature monitors and their data logging systems.

An exponential pile mockup of the C Reactor was used to obtain buckling data with control rods in the mockup. Two arrangements were used: one with a single control rod, and the other with six control rods. Further analyses will be needed to deduce control rod strengths for the large reactor.

Criticality measurements continued in a 14" spherical vessel containing plutonium nitrate solutions. The effect of acid molarity on criticality was studied using a molarity of 6. These data plus data previously obtained with molarities of 2 and 4 have been compared with P-11 data. The agreement is very good. The largest discrepancy obtained is less than one percent. This is well within the experimental uncertainties arising in chemical determinations of plutonium concentration.

Experiments were performed with a .03" cadmium wrapper on the criticality vessel. The cadmium layer separated the vessel from a thick water reflector. The effect of the cadmium was to reduce the worth of the water to the equivalent of a paraffin reflector about one-half inch thick.

A parametric survey of fast oxide reactors was completed. Most of the reactors investigated were fueled with U-235 and U-238, but some

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Pu-U-238 and Pu-Th-232 systems were also considered. This study provides the physics statics data which could serve as the basis for preliminary economic evaluation of various fast reactors for production of special materials such as high grade plutonium and U-233.

Due to the long delay in obtaining use of the PRCF and gamma scanning facilities, it is planned to bypass these on some of the low exposure Pu-Al physics elements and send them directly to Radiometallurgy for preparation for burnup analysis. The first of these elements, No. 5051, is now being prepared for disassembly.

A fairly detailed series of investigations of the use of Phoenix fuel for compact, water moderated power reactors has been started. These investigations are an outgrowth of previous work done for a small, Phoenix-fueled, pressurized water reactor (HW-71279), and will include several reactor types. Analysis continues on the study of the feasibility of performing a Phoenix fuel burnup experiment in the central cell of the PRTR.

Subcritical measurements were made to predict criticality for a system of plutonium-aluminum rods in light water. This month rods containing 6% Pu-240 were loaded in a central region surrounded by a region containing rods with 5% Pu-240. The estimated number of rods for criticality was 490. Previous experiments have shown that 485 rods are required when the loadings in the regions are reversed, and 494 rods are required for a random loading of the rods.

Tests were successfully completed on the second generation liquid effluent gamma activity monitor for actuating the PRTR containment trip circuits. This has improved trip circuits and final packaging, and will replace the first prototype which was temporarily installed several months ago as a replacement for the original inadequate equipment.

Development was started on instrumentation for measuring the vibration of PRTR fuel elements, both in the hot loop mockup and ultimately in the PRTR.

A PRP Critical Facility analog study was completed to determine the nuclear accident potential with various fuel loadings. This study included the effects of steam and void formation in the moderator and boiling at the fuel surfaces.

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Invention disclosures were filed on a new graphical alternating current nulling device for use with either conventional or multi-parameter eddy current nondestructive testing equipment on a Hall Effect magnetometer for nondestructive testing of steel.

The tentative procedures developed for Lamb wave ultrasonic nondestructive testing of fuel sheath tubing were subjected to their first evaluation in the field through tests at the plant of a tubing manufacturer. Results there were somewhat limited by the available equipment, but will be compared with further testing of the same tubing at Hanford later.

A simplified pocket size dose meter which has a single audible alarm point at about 50 mr and no visual indication was developed. This is intended to be the reference design for expedited off-site procurement of instruments for large scale field trials in the reactor and separations areas. Final design of the selectable alarm and indicating models continued to fulfill anticipated specialized needs.

A series of nine dispersion experiments, designed to clarify certain features noted in the 1959 Green Glow data relating to emission duration, travel time to a given distance, and averaging time of meteorological parameters in relation to dispersion parameters during stable atmospheric conditions were completed.

The field work for the study of radioactivity in Alaskan Eskimos is drawing to a close. Measurements are now being made at Point Hope. Available results show that in some villages, the average body burden is comparable to or higher than found in Lapland. The high burdens appear to be related to the high activities in caribou and reindeer as in Lapland.

One experimental high level, 5 r to 100 r, miniature signaling dose meter was completed, tested, and demonstrated for possible applications in nuclear accident monitoring and civilian defense.

Good correlations were observed between the results of an ultrasonic test under development to monitor installed NPR primary piping for fatigue and the results of destructive fatigue tests at Hanford and off-site.

3. Chemistry

Extended tests have been concluded which show that Permutit SK resin has more than sufficient stability toward nitric acid degradation to

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permit its long-term use for the extraction of plutonium from 234-5 oxalate supernates.

Hot cell experiments were performed to test the denitration of actual Purex 1WW with sugar, vice formaldehyde. The reaction is easily controlled and there was little or no tendency of the reaction mixture to foam. In addition, no precipitates, tars or other insoluble reaction products were observed to form.

A hot cell demonstration of the nickel ferrocyanide process for precipitation of cesium from Purex tank farm supernatant was completed and showed that an over-all cesium recovery of 90% could probably be realized in plant equipment.

Reactor studies, wherein deionized water was passed through a new tube containing new fuel elements, show the source of Ga-72 in reactor effluent water to be impurities in the aluminum and that determination of Ga-72 in effluent water might be a measure of the corrosion rate of new aluminum.

Improved estimates were made of thermal conditions in containers of zeolite loaded with Cs-137. Typical results show that correction for gamma leakage in a container loaded to two milliequivalents of cesium per gram of zeolite permits increasing the vessel diameter from 10.3 to 12.25 inches with no increase in centerline temperature.

In pilot plant studies on the removal of cesium from synthetic, alkaline Purex waste by clinoptilolite, the absorption cycle was characterized by an almost constant minimum cesium loss of about 1.5%. Five and 50% breakthrough occurred at about 17 and 30 bed volumes, respectively.

The use of dipicrylamine dissolved in nitrobenzene to extract cesium from a synthetic, alkaline Purex waste supernate solution was successfully demonstrated in a nine-foot high, three-inch diameter pulse column. Cesium extraction and subsequent stripping losses were as low as 0.8 and 0.6 percent, respectively.

Over 98% of both plutonium and neptunium can be removed from Purex 1WW, after treatment with hydrazine, by an equal volume extraction with 0.04 M D2EHPA - 0.02 M TBP - Soltrol. Likewise, over 97% of

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the plutonium and neptunium in the organic phase can be stripped upon contact with an equal volume of 0.25 M oxalic acid.

In-tank solidification of synthetic coating waste by evaporative techniques may leave a liquid residue. The addition of about 65 weight percent of sodium bicarbonate reduces this remaining liquid to a solid rapidly and over a wide temperature range.

The addition of 0.4 g/l DBP to synthetic Purex 1WW initiates foaming in the semiworks formaldehyde denitration reactor, paralleling the behavior of the Purex plant unit with current waste. Introduction of a silicone antifoam reagent at a concentration of 0.2 g/l reduced the foam level two-fold.

Installation of the radiant heat spray and pot calciners and associated equipment in the High Level Radiochemistry Facility was completed. Cold shakedown runs for both the spray calciner and pot calciner equipment (the former with continuous melt down of the calcine) with a synthetic feed were performed successfully, all operations being done remotely with manipulators. The first full level spray calcination run is scheduled for late September.

4. Biology

In the transfer study of I-131 from food which was contaminated once with I-131, it appears that peak thyroidal I-131 concentration in cows occurs after one week and remains for about two weeks, with about 55% of the first day's dose in the thyroid. Peak milk concentrations occurred four days after contamination event was about 0.4% of the initial dose in each liter of milk.

Eight-hydroxyquinoline appears to have some promise in helping to remove plutonium from sites unavailable to DTPA. It causes an increase in fecal excretion of plutonium. Even though it is not nearly as effective as DTPA alone or even in combination with DTPA, it still may offer some usefulness under special conditions which are being investigated.

The effectiveness of DTPA on the removal of inhaled $\text{Ce}^{144}\text{O}_2$ from dogs was confirmed. If administered immediately after exposure to the aerosol, the body burden of radionuclides drops to less than 5% of the amount initially deposited. Without treatment, approximately 80% is retained at the equivalent time.

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Sodium polystyrene sulfonate obtained from the Eltex Laboratories was found without effect on removing PuO_2 or Pu nitrate from the lungs of dogs.

5. Programming

A major effort was made to complete the computer calculations associated with the successive bred fuel recycle study. All but three of the planned fifty recycle cases were finished. The study considers plutonium recycled for minimum fuel cost with the amount of plutonium recycled limited to that produced in the previous cycle, and an alternative mode without a quantity limitation because of the availability of a hypothetical stockpile of plutonium of the composition of the previous cycle. To provide perspective, U-233 recycle in thorium with U-235 make up was also studied. Computed plutonium values ranged from \$10 to \$12/gram of fissile plutonium, while U-233 values ranged from \$13 to \$14/gram of U-233; however, the fuel costs with U-233 were higher than all of the corresponding uranium-plutonium cases.

Compilation of the revised Conventional Reprocessing Code for economics studies of fuel reprocessing was completed and debug runs were started. A number of errors have shown up and have been corrected. Numerous hand calculations remain to be done to complete the checking and debugging of this code. When completed, this code will provide the base case comparison for the Salt Cycle Economics Code (completed last month) to evaluate economic incentives for developing close-coupled Salt Cycle-type processes.

TECHNICAL AND OTHER SERVICES

Five new cases of plutonium deposition were confirmed by bioassay analyses during August. The new plutonium deposition cases resulted from five earlier incidents involving four CPD employees and one HLO employee. Inhalation was the mode of intake in each case. The maximum estimated body burden of plutonium in these five cases was less than one percent of the permissible body burden. The total number of plutonium deposition cases that have occurred at Hanford is 297 of which 214 are currently employed.

One plutonium contaminated minor injury required tissue excision. During a follow-up examination in the Whole Body Counter, a general survey of

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other portions of the employee's hands, according to a newly instituted procedure, resulted in the detection of .04 μc of plutonium (about one permissible body burden) on another finger. A second excision successfully removed this previously unsuspected plutonium injury.

A 16-ton cask surveyed on a common carrier following arrival from Idaho Falls was found to have loose contamination with dose rates up to 1.8 rads/hour. The carrier truck bed was contaminated up to 5 rads/hour. Investigation of involved personnel and surveys of receiving and transfer areas as well as roadways indicated no abnormal exposure to personnel. No contamination other than on the cask and on the truck bed was uncovered by surveys made by HAPO personnel.

On August 10 the new Hanford film badge dosimeter was placed into service and distributed for routine use throughout the plant. The new dosimeter includes an improved filter system and provides capability for measuring high level radiation dose in the event of a serious accident.

The presence of fallout materials on air filter samples throughout the Northwest showed a sharp increase on August 31; $30 \mu\text{c}/\text{m}^3$ as compared to an average of $3.2 \mu\text{c}/\text{m}^3$ for July.

A method was devised which modifies the present linear programming model of the FPD Production Forecasting Process so as to allow the model considerably more freedom in balancing safe inventory levels, idle time, and added capacity requirements.

In connection with the straightening of warped NPR fuels, submitted data were analyzed to determine the amount of bending necessary to effect a zero average warp on fuel elements after the second beta heat treatment. Such a determination proved to be impossible because of an almost perfect correlation between the initial warp after beta heat treatment and the warp after bending.

Numerous electronically perfect runs have been made on the Magnetic Tape Controlled Gorton Lathe using a program to machine dummy 1251 parts. Although no attempt has been made to machine the parts to finished dimensions, the surface finish of these samples is within specifications.

Nondestructive testing was performed on the uncharged fuel elements from multiple failure lot HZ-065, and on elements sampled from eight "control" lots. The purpose of this testing is to determine if there are measurable

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characteristics which could have differentiated between this and nonrupture lots. Extreme care is being taken to remove possible effects of tester error in assessing quality.

A FORTRAN language power spectral estimation program has been obtained from the UCLA Medical Center and is being used to analyze several pulse column equilibrium experiments. A number of variables which are recorded periodically during an equilibrium run of the column are being analyzed to establish column characteristics under steady state operation and to ascertain changes in these characteristics as the column approaches a flooding situation.

It is often necessary, when analyzing fuels data, to transform the data in some fashion in order to stabilize the variance, and incidentally, achieve normality. However, from an interpretation viewpoint, it is desirable to express results in terms of the raw data. A document has been prepared to permit this correlation. For various transformations in which the mean and variance of the transformed variable are known, the corresponding means and variances of the raw data are given. In addition, the percent(s) of items exceeding some value(s) are also given. A series of graphs makes the results readily usable.

The programs to perform the craft set analyses for reactor maintenance work have been completed and debugged. The second major program for translating work order numbers into either job codes or the classifications of facilities engineering, research and engineering, landlord, new work or project, has been completed and debugged. The master conversion table from work order numbers to job or class numbers is 99 percent complete.

Authorized funds for 13 active projects total \$2,744,600. The total estimated cost of these projects is \$9,117,000 of which \$1,600,000 had been spent through July 31, 1962.

SUPPORTING FUNCTIONS

The Plutonium Recycle Test Reactor output was 498 MWD for a plant efficiency of 23% and an experimental time efficiency of 25.8% during the month of August.

The outage, which began June 3, continued until August 5. The reactor was shut down again on August 8-9 to repair a D₂O leak at a spare inlet thermowell. Another shutdown occurred August 12-16 when the diesel generator

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failed to start automatically on test. The outage was extended to correct helium and D₂O leaks and to rework three galled helium valve stems.

A shutdown occurred August 21, as a result of excessive leakage of hot D₂O into the waste collection system. The source of the D₂O leakage was at the tie-in to the low pressure light water injection system. Approximately 15 minutes after shutdown, a fuel element rupture with gross contamination spread throughout the primary system occurred. Fuel element #5139, a MgO-PuO₂ test element in tube 1356, was discharged and visual examination showed a cladding failure approximately 1-1/2 inches long on an outer fuel rod. Reactor discharge was underway at the end of the month to permit decontamination of the primary system.

During the month valuable experience was gained with the rupture monitor system. Definite fission product bursts and a high background count rate were observed prior to August 21. The high background count rate, predicted earlier, will be reduced by design changes now being studied.

During these bursts and during the August 21 rupture, exceptional sensitivity was noticed in the channel which monitored tube 1356, which contained the MgO-PuO₂ rupture element. This high sensitivity may have been caused by either a higher instrument sensitivity than the others or by the monitoring of the particular tube containing the defective fuel element.

In activities related to the Plutonium Recycle Critical Facility, an additional difficulty was encountered with safety rod sticking. Repair work and subsequent testing indicated satisfactory operation. A moderator dump test, in which a full moderator load of H₂O was dumped through the dump valve into the cell was completed. The cell remained flooded for 24 hours with electrical equipment submerged. No effect on electrical equipment or circuits nor other difficulties was observed. Thirty Pu-Al fuel elements were received and stored in the PRCF cell.

Advanced Degree - Four Ph.D. applicants visited HAPO for employment interviews. Three offers were extended; one acceptance and five rejections were received. Current open offers total two.

BS/MS - During the month five direct placement offers were extended; two acceptances and five rejections were received. Three program offers were made; one acceptance and four rejections were received. Open offers at

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month's end included three direct placement and six program.

Technical Graduate Program - Two Technical Graduates were placed on permanent assignments; six new members were added to the rolls and four terminated. Current program members total 56.



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REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Corrosion of Titanium Bonded End Closures. Additional corrosion data on the coextruded, Zircaloy-clad, fuel elements with unwelded titanium bonded end closures have been obtained. One group of elements was exposed to 400 C, 1500 psi steam, while a second group of elements is being exposed to 360 C water. The 400 C steam test was terminated following a rupture of two of the elements after 30 days of exposure. There have been no ruptures in the 360 C water test following 38 days of exposure.

One element from each test group was sectioned to determine the degree of corrosion penetration along the Zr-2 - Ti bond layer. The element exposed to 400 C steam showed a penetration of approximately 50 mils of the 120-mil bond layer. This compares to 27 mils penetration for the element exposed to 360 C water. In both cases the width of penetration is approximately 0.8 mil and is uniform along the entire length.

Erosion-Corrosion of Aluminum Alloys. Samples of stripped can wall from defective fuel elements were exposed to 300 Area tap water at 102 C and 76 ft/sec flow velocity for 24, 48 and 72 hours. The AlSi side of the samples was exposed to compare corrosion of AlSi with that of the aluminum outer jackets. AlSi corrosion was less by a factor of seven for 24-hour tests and less by a factor of four for 48- and 72-hour tests. The small amount of corrosion seen in 24 hours on AlSi was due to a thin uranium AlSi layer on top of the AlSi.

Tests in which 100 Area process water was substituted for 300 Area tap water showed AlSi corrosion was less by a factor of three for 24-hour tests.

Dynamic Corrosion of Electroless Nickel Coatings on 1245 and X-8001 Aluminum. Corrosion testing of electroless nickel films on aluminum alloys has been carried to 90 days at 300 C and flow rates of 25 fps. The specimens are coupons 1" x 1" x 0.062". The thickness of the nickel coat is approximately one mil. Flaws were deliberately created in some coupons to expose a small area of the aluminum substrate. Other coupons were heat treated in air at temperatures as

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high as 400 C and up to 40 hours. In the dynamic corrosion tests, none of the X-8001 coupons failed. Massive failures occurred on all 1245 coupons not heat treated at 400 C. Two coupons heat treated at 400 C for 40 hours did not fail up to 90 days, despite the development of cracks in the nickel film. Metallographic sections of the cracks show penetration through the diffusion layers into the aluminum. The sections also show three separate diffusion layers between the nickel and aluminum. The diffusion layers appear to be corrosion resistant and strengthen the nickel film to preclude further cracking at the flaw, which would otherwise initiate a massive failure.

Metallurgy Studies

NPR Fuel Element Supports. The severe bending necessary to form the buggy spring configuration of NPR fuel element supports results in roughening or cracking of the outer surface of the bends. One potential method of alleviating this condition is to use Zircaloy-2 strip with a finer grain size. A laboratory rolling technique has been devised whereby strip with grain diameters of 4-8 microns can be produced as compared to the 20-30-micron diameter grains found in the present supports. This fine grained strip can be prepared from commercially hot rolled plate (20- to 30-micron grain diameter) as well as from warm extruded and recrystallized Zircaloy (6- to 8-micron grain diameter). The basis of the rolling process is to accumulate large amounts of cold work in the metal by warm rolling below the recrystallization temperature and subsequently annealing to a fine grain size. Since no edge cracking occurs, as is the case for large reductions at room temperature, the process should be adaptable for commercial rolling. Specific details of the laboratory rolling that produced a fine grain size are: 0.5-inch thick hot rolled plate and 0.4-inch thick warm extruded Zircaloy were rolled to approximately 0.035-inch thick strip with the metal periodically heated to 1200 F in salt to maintain a rolling temperature range of about 700-1200 F. Fine grained strip produced in this manner will be tested to determine the bending characteristics as related to the buggy spring problem.

Metallic Fuel Development

Fuel Irradiations. An experimental single tube, dual enriched metallic uranium element completed the second cycle of irradiation in the M-3 pressurized water loop in the ETR. Peak power generation in the element during this period was 130 kw/ft. The element has accumulated a total exposure of 560 MWD/T. Visual examination of the element revealed no evidence of damage or corrosion. A measured

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100-mil warp was produced by the severe radial flux gradient existing in the M-3 facility. The direction of warp was toward the reactor center and was a reversal of a similar amount of warp that occurred during the previous cycle of irradiation. The element was recharged into the reactor for additional exposure. The element was again positioned with the direction of warp away from the reactor core.

A total of 18 NPR fuel element assemblies (36 inner and outer tubular components) were weighed in the KE basin for evaluation of fuel swelling following irradiation in KER Loops 3 and 4 to exposures up to 800 MWD/T. The fuel swelling observed approximated the minimum theoretical swelling computed on the basis of fuel burnup, indicating that swelling resulting from the agglomeration and expansion of the fission gases was not significant in these test elements.

Radiometallurgical examination is continuing on the variable braze thickness irradiation test, GEH-4-68, 69 and 70. The last of the three fuel elements, GEH-70, is being examined. One end of the element shows cracking in the uranium in the braze-heat-affected zone; the cracks all appear to originate in a section of the uranium containing a series of voids. It is believed that the voids existed before irradiation and were caused by the brazing process. The end closure appears to be in good condition with no cracks in the braze.

Fluted Single Tube NPR Fuel Element. The coextrusion of the fluted single tube fuel element stock was successfully completed. Preliminary examination indicates the extrusion is within design dimensional tolerances and is of good quality. The Zircaloy-2 clad is very smooth and varies only plus or minus 0.002-inch from the desired thickness. The clad on the peaks of the flutes is 30 percent thicker than that in the valleys.

The attempt to make cap stock for these elements by extruding a clad Zircaloy-2 billet failed. The intention was to peel the clad, which was thicker than that on the fuel, leaving Zircaloy-2 which fit the inside of the fuel tube. The oxidation of the billet core in a chemical milling bath failed to prevent bonding of the clad to the core. The resulting bond was tenacious enough to prevent peeling of the clad.

Hot-Headed Closure Studies. Effort this month was concentrated on studying the effects on bonding between the cap and the fuel element (using copper foil as interface material) by variations in post heat input, time and pressure. Although bonding has been observed in the samples, a satisfactory joint has not been achieved. The following types of defects have been observed:

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1. Transverse cracking in the interface between the Zircaloy-2 cap and fuel element cladding; apparently, a brittle Zirc-Cu alloy resulted from excessive amounts of copper.
2. Shrinkage cracking in the interface near the projection welds; apparently, the Cu-Zirc alloy had reached the melting temperature in the area adjacent to the projection weld while insufficient pressure was applied.
3. Movement of uranium into the interface between the Zirc cap and the fuel element cladding; this may be the result of insufficient recessing of the fuel prior to welding and of improper relationships between forging pressure and heat input.

Copper Braze Closure. Two N inner fuel elements were braze-closed by placing a 0.010-inch copper wafer under each end cap and forming the Cu-Zr eutectic braze by diffusion at 1000 C using induction heating. One of the elements was left in the as-brazed condition and one was electron beam welded over the brazed closure. The elements were then autoclaved 10 hours in 300 C water to test the corrosion resistance of the braze and of the braze-contaminated weld. The test showed that the braze corroded somewhat but still maintained a closure. The welded element showed a slight color difference in the areas diluted by braze but showed no severe corrosion. The elements are being reinserted in the autoclave for another 10 hours, to be followed, after re-examination, by a longer autoclave test.

Melting point studies on a series of arc-melted alloys have shown the existence of a ternary eutectic at approximately 80 w/o Zr - 10 w/o Cu - 10 w/o Ni which melts at about 850 C. An attempt was made to form this alloy by diffusion of copper and nickel wafers into the Zircaloy-2 end cap, but a temperature of 1020 C was necessary before rapid enough diffusion could take place to form the alloy.

Two diffusion brazes have been made at 920 C using a copper wafer and a Zircaloy-2 end cap vapor plated with a 0.002-inch thick beryllium film. The closure is being examined metallographically to check its integrity.

Projection Welded Braze Closure. The projection welded braze closure is being developed as an alternate closure. A four-inch NPR inner element using these closures has passed a one-hour 400 C steam autoclave test and two others are currently undergoing 80-hour 300 C

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water autoclave testing. The use of paper wrapped steel center plugs appears to eliminate arcing against the clad. Changing the cap shape has overcome the weld problems. It remains to be determined whether 100 percent bonding of the Zircaloy cap to the uranium is being accomplished.

Self-Brazed Closures. Four approaches to the problem of preventing the flow of uranium or uranium alloys into the annuli between the Zircaloy cap and the Zircaloy sidewalls were experimentally tried:

1. Using the familiar V-contoured cap, the slant faces of the V only were plated with Cu and Ni, and then tinned. After assembly and electron beam welding, the end of the test element was processed in the seam welder in the 325 Building with hand manipulation and three different power settings. The closure was then hot-pressed in the Sciaky heavy duty welder as described in earlier reports. Subsequent ultrasonic testing showed the bonds, both at the U/Zry interface and at the Zry/Zry interfaces, to be essentially sound. Incremental removal of the slug end by lathe turning, with electrographic testing for uranium at intervals indicated that with proper adjustment of the seam welder and welding conditions, the Zry-Zry bond may be made sound enough to prevent the plastic flow of uranium into the annuli. This system has the advantage that no corrodible material is introduced into the bond; hence, it will offer maximum resistance to corrosive-type failure. However, the mechanics of the operation are rather unwieldy and comparatively slow. A fixture for mechanically guiding the element in the welding process is being made up, and further trials under more ideal operating conditions are anticipated.
2. Procedure was the same as for the first approach, except that both the side walls and slant faces were "tinned" with the Zr-Cu-Ni alloy before assembly and electron beam welding. After Sciaky pressing, this specimen, too, appeared essentially sound in the ultrasonic test. Dissection showed some spikes of uranium alloy within 0.080-inch of the end face. The annuli were almost entirely filled with the bonding alloy.
3. The standard cap was grooved midway on the side walls and Cu-Ni plated Zircaloy wire snap rings were installed in the grooves. The cap was then induction-heated to form an excess of Zr-Cu-Ni alloy in the grooves. After assembly and

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electron beam welding, the slug was hot-pressed in the Sciaky welder. After removal of 0.072-inch from the end face, no uranium had yet been encountered in annuli. However, the width of the annulus was excessive and presumably it would have lower corrosion resistance than is desirable. There appeared also to be more erosion and thinning of the jacket than is experienced in other processes except pre-placement brazing.

4. Flat-faced caps equipped with 0.075-inch tapered skirts were pre-tinned on the faying surfaces and electron beam welded into element ends having matching contour. These were then Sciaky pressed. Ultrasonic testing indicated sound bonds, and subsequent incremental removal by lathe turning did not encounter any uranium in the annuli on one end clear down to the U-Zry interface. On the other end, some tiny spikes of uranium were found at 0.075-inch depth. This approach appears attractive from the standpoint of operating time and simplicity, but loses whatever advantage might accrue from the V-groove contour. Also, the Zr-Cu-Ni alloy layer in the annulus may be less resistant to corrosion than desired. Autoclave testing of more pieces of this type is anticipated.

Fuel Element Heat Treatment. N-outer tube coextruded stock with core material containing 640 ppm Al and 400 ppm Fe has been given a variety of heat treatments to observe the effects on compound size and dispersion, grain size, clad-core bond and hardness. The treatments included the effect of beta temperature holding time, gamma temperature holding time, and subsequent alpha temperature soaking. Metallographic examination is in progress. Hardness data thus far has shown minimum hardness following beta heat treatment and 600-640 C alpha soaking. Initial hardening was observed at lower alpha temperatures. Thickening of core-clad bond by diffusion at 300 C in the gamma phase reduced its strength to the point that bond fracture occurred on quenching. Bonds of equal thickness produced by long periods in the beta phase were not fractured in quenching, probably due to the reduction in stress.

NPR Outer Fuel Element Support. Testing of the steel clad support for the N-Reactor fuel element assembly is continuing in the 306 Building. Following previously reported tests (five-foot long process tube section) facilities were scaled up to accommodate longer tube sections. A 17-foot long section of process tubing was used to "shake down" facilities and equipment before using longer

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tubes. Seven elements, five under static water conditions, and two under 30 gpm water flow rate, were charged through the tube with no evidence of tube damage.

A 52-foot eight-inch length of tube was cleaned in the same manner (one hour detergent soak, flush rinse, high velocity water jet impinged on wall full length), and set up to test at a 30 gpm flow rate. The first fuel element scratched the tube on one side, i.e., one set of supports. A single scratch started at approximately nineteen feet from the discharge end of the tube. At approximately seventeen feet the scratch divided into two scratches, apparently where the second support crossed the original scratch. The two scratches continued in a criss-cross pattern to the end of the tube (17 feet). The scratches are about 0.0002 to 0.0006-inch deep, and 0.002 to 0.004-inch wide. It appears to have started by imbedding an object in the iron shoe and breaking the oxide film.

The other set of supports passed directly over a projection on the tube wall which severely gouged the supports. The projection remained in place and no scratching was initiated by the gouged supports. The tube was rotated approximately ninety degrees, re-cleaned with the jet, and testing resumed. Seven additional elements have now been charged (singly) through the tube with no evidence of scratching.

Fabrication of N Inner Supports. Difficulties encountered off-site in producing required quantities of N inner supports of acceptable quality have resulted in a laboratory program to fabricate a demonstration quantity of supports. One phase of the program is to develop a method for making Zircaloy-2 strip that has consistently high bend ductility (one which will make a crack free bend through a bend radius of 1.5 times the strip thickness). Another phase is to develop test and quality control methods on which process specifications for the production of supports may be written.

The sheet forming processes investigated so far show definite evidence that the texture of Zircaloy-2 has a large effect on its bend ductility. Grain size has a smaller, but important, effect. The desired texture is one in which a strain in the length direction of the strip produces a high reduction in strip thickness. High bend ductility has been found to exist in extruded material. A major effort is being directed toward producing the desired textures by economically feasible fabrication methods.

A cyclic flexure test was developed for completed supports that clearly distinguishes cracked or poor quality supports from acceptable supports.

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Fuel Deformation Studies. Samples for density, metallography and burnup were cut from Zircaloy-2 clad uranium rods irradiated with intentional striations in the cladding up to thirty percent of the nominal cladding thickness. Metallographic examination of a sample with 3.5 percent total cladding strain has shown that some localized deformation is occurring in the region of the striations. This is evidenced by the uranium directly under the seven striations in the cladding moving outward from its normal circular contour. However, even in this sample, with striations of 30 percent of the cladding thickness, the localized straining accounts for only a fraction of the total cladding strain. This observed lack of localized deformation is in agreement with observations on fuel elements irradiated at cladding temperatures of 350 C and above.

Density measurements show swelling of the unalloyed uranium to be between 3.1 and 3.3 percent at an approximate volume average temperature of 535 C. The burnup on these samples is estimated at 0.16 a/o. Density decreases for the U-2 w/o Zircaloy alloy fuel are much larger, being 7.7 to 8.3 percent at approximately the same volume average temperatures. Burnup measurements on the alloy samples given an average value of 0.2 a/o.

Fabrication of components for a second irradiation test of fuel rods with non-uniform cladding thickness has continued. Machining, welding and autoradiographing of the elements are complete.

Glass Extrusion Lubricants. Four lead glasses were prepared in attempting to find a suitable lubricant for coextrusion purposes. Plasma spraying of the glass particles was attempted as a means of applying the glass to the billet in a uniform coating, but proved unsuccessful. Two glasses were evaluated by brush coating two Zr-2 billets and hot extrusion was performed in the 700-ton press. Both billets had extrusion constants comparable to copper clad billets, but caused galling of the die, notably towards the end of the extrusion. This behavior may be explained by the fact that as the glass lubricant neared the die throat, the increase in speed caused the glass to lose its lubricating properties.

Extrusion Behavior and Properties of Zirconium Alloys. Corrosion tests in 750 F, 1500 psi steam and 680 F water are continuing for a series of zirconium alloys of two oxygen levels and varying tin content. Current exposure is approximately 70 days. At the last inspection the low oxygen series had lower weight gains than the high oxygen series and had lower weight gains with increasing tin content. Room temperature tensile tests have been completed for these materials and elevated temperature tests are in progress.

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The room temperature tests have shown increases in yield and tensile strength and decreases in ductility with increased oxygen or tin content.

Crud Probe. Four one-inch diameter crud probes with short thermocouples have been assembled. The Zircaloy-2 clad thermocouple, Zircaloy-2 end cap, and Zircaloy-2 conical sleeve above the end cap will be brazed together in the closure brazing operation. These pieces will be used in ex-reactor studies.

A one-inch diameter rod with a 0.5-inch diameter uranium core and 0.25-inch Zircaloy-2 cladding has been successfully extruded by Fuels Fabrication Development Operation. This extrusion is being evaluated for possible use in the development of a power probe to be used in crud deposition studies.

In-Reactor Rupture Device. An N inner fuel element was ruptured in the ETR P-7 Loop at high temperature and pressure, using a new rupturing device which can be adapted to any surface of an N fuel element. The rupture device is a hydraulically operated shaper that cuts a small slot through the cladding of the fuel element. The use of this device permits the rupture testing of an irradiated N element without pre-selection and defecting prior to irradiation.

2. REACTOR PROGRAM

Gas Atmosphere Studies

Hydriding of Zircaloy-2 in Hydrogen-Carbon Monoxide-Helium Mixtures. Last month data were reported showing accelerated hydriding of Zr-2 after two weeks at 325, 375 and 425 C in a carefully purified He - 4% H₂ - 2% CO mixture. In a recent experiment Zircaloy was exposed at 375 and 425 C to the same purified gas after the gas had contacted a 600 C graphite bar to allow some water formation by the reverse water gas reaction: $H_2 + CO \rightleftharpoons H_2O + C$. In contrast to the previous results the water generated by this reaction formed oxide films on the Zircaloy; however, no water was detected in the effluent gas. It appears that the water formation rate was insufficient to match the Zircaloy consumption rate and the samples gettered all available water. This conclusion is strengthened by the oxide weight gains on the samples showing a definite position effect with samples nearest the gas inlet having the most oxide. The weight gains of all the samples were sub-normal for this time at temperature. The current theory of gas phase hydriding would predict that the samples should have hydrided. Half of the samples have been analyzed to date, all have shown hydriding including pre-autoclaved samples.

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A new experiment has been started similar to the previous ones, except a bed of graphite chips at 750 C was substituted for the graphite bar to increase the rate of the water formation reaction. No data from this experiment are yet available.

Electrical Resistance Measurements of ZrO₂ Corrosion Films. Additional measurements have been made on the electrical resistance of the corrosion film on two pairs of alpha annealed and beta quenched Zircaloy-2 samples. The resistance of the first pair was measured after oxidizing 24 hours in low pressure water vapor; the second pair after 24 hours autoclaving in 400 C, 1500 psi. In both cases the results confirmed those reported last month that the corrosion film on the beta quenched sample had a lower electrical resistance. Similar measurements on crystal bar zirconium showed no significant difference in electrical resistance between the alpha annealed and beta heat treated samples. This was to be expected since pure zirconium has little or no second phase material to take into solution by heat treating. Thus, there would be no effect from solution heat treatment on the semi-conducting properties of the corrosion film.

Preliminary tests in the laboratory have been completed on a capsule for measuring the electrical resistance between a zirconium oxide film and graphite. Two cycles have been completed in which the oxide resistance changed from 10 megaohms to 15 ohm depending on the oxidizing character of the gas environment. The resistance is controlled by the moisture content of the helium over the sample. Resistance measurements obtained will be compared to in-reactor measurements. The capsule is ready to be charged into KE-Reactor and charging should be accomplished during the next reactor shutdown.

Graphite Burnout Monitoring. The effectiveness of a Process Change Authorization (PCA) designed to minimize air in-leakage and reduce the inlet dew points continued to be demonstrated by results at H-Reactor. On August 2, 1962, small graphite burnout monitors were discharged from channel 2577 at H-Reactor after 47 operating days. A graph of the burnout profile showed a peak maximum of 2%/KOD at a distance 80 inches into the graphite stack and a smaller peak of 1%/KOD at 200 inches.

The previous test conducted prior to the PCA from October 1961 to May 1962, indicated the same peak locations but slightly higher peak rates of 3 and 2%/KOD, respectively. The highest burnout rate measured at H was 19%/KOD in the period from 9/14/60 to 10/23/61.

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Monitors in channel 3461 at B-Reactor from June 12 to July 23, 1962, showed only one peak. Its height was approximately 7%/KOD at 130 inches into the stack. These measurements showed the same peak rates and locations as those in the previous test period from April 7 to June 16, 1962. In this reactor, however, the PCA had not been completely implemented.

At the next scheduled outage of B-Reactor two additional burnout monitoring channels, 0373 and 1376, will be put into service. It is planned that monitors 1.125-inch in diameter will be inserted along with the regular 0.43-inch ones, reducing the surface-to-volume ratio by approximately one-third. This should furnish a better basis on which to predict the burnout rate of the moderator bars themselves.

Corrosion and Coolant Systems Development

In-Line Analysis of Reactor Coolants. The dissolved oxygen analyzer consists of a galvanic cell with silver and zinc electrodes. During operation the sample stream to be analyzed flows continuously through this cell. Oxidation of the zinc electrode releases zinc ions and reduction of the dissolved oxygen produces hydroxide ions in the sample stream. The cell current generated by this oxidation-reduction process is directly proportional to the dissolved oxygen concentration. An electrolytic cell is an integral part of this analyzer and is used to generate oxygen gas for calibration of the analyzer. This instrument is being evaluated for application in pressurized water reactor coolant streams containing trace amounts (0-100 ppb) of dissolved oxygen. Laboratory scale testing of this analyzer is nearly complete. Variables evaluated to date include response time, temperature effects, flow effects, conductivity effects, and use of lithium hydroxide versus calcium carbonate for conductivity control. In general, the analyzer works satisfactorily.

During the KER-3 hydrazine injection test, the composition of the coolant was monitored continuously with an automatic, wet chemical analyzer. This test demonstrated that the procedure is highly accurate and sensitive to hydrazine content in the 0 to 1.2 ppm range.

A proposed procedure for ammonia analysis was evaluated for the 0-250 ppb concentration range. The analyses were reproducible to within ± 10 ppb ammonia in this concentration range.

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Evaluation of a sodium sensitive electrode continued. This electrode measures sodium ion concentrations in the same manner, and with the same equipment, as standard electrodes measure the hydrogen ion concentration. This electrode is being evaluated for use in the NPR secondary coolant system to detect raw water leakage from the dump condensers into the secondary coolant system. The recommended operating procedure involves adjustment of the solution pH to 9-11 with ammonia or morpholine, to minimize interference from hydrogen ions, before the sodium ion concentration is measured. Preliminary tests demonstrated that the readings obtained for identical sodium ion concentrations are extremely pH dependent. In general, the solutions with the highest pH values yielded the most reproducible and more nearly linear potential versus concentration curve.

KER-3 Hydrazine Injection Test. A four-day hydrazine injection test was performed in KER-3 during a reactor outage. The purpose of this test was to determine whether hydrazine is an effective scavenger for the oxygen produced by radiolytic decomposition of reactor coolant streams during reactor startup operations at low coolant temperatures. During the early portion of the test the hydrazine injection rate was relatively low, and considerable oxygen (19 ppm) and hydrogen peroxide (6.5 ppm) were formed by decomposition of the coolant. When the hydrazine injection rate was subsequently increased to maintain a 0.5 ppm hydrazine residual concentration, the oxygen and peroxide concentrations decreased rapidly to very nearly negligible levels.

Corrosion of Zircaloy Under Heat Transfer Conditions. The fourth test in TF-3 was completed during the month. Samples of Zr-2 were clamped against an Inconel-clad heater rod with a thin sheet of gold placed between the two materials to serve as a gasket. The Zr-2 was exposed to 580 F bulk water at a pH of 10.0 (using LiOH) and a heat flux of 280,000 Btu/hr-ft². The surface temperature is estimated at 640 F based on heat transfer equations. The loop pressure was maintained at 2000 psi to produce incipient boiling conditions. Visual observations of the samples after 437 hours of exposure revealed no untoward corrosion on the external surface of the Zr-2. The gold gasket had bonded to the Zr-2 inner surface in places; bonding was also observed between the Inconel and the gold. Despite the close fit between components, it was quite evident that the loop water had seeped into the crevice between the gold and Zr-2. While the Zr-2 was not severely corroded, white corrosion product had formed on areas of the surface where concentration of the LiOH had taken

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place. Some crud deposition had occurred on areas of the sample exposed to the loop water, but these areas appeared otherwise normal. The samples will be examined metallographically with specific inspection for possible hydriding in regions of white oxide formation.

Metallographic examination of the Zr-2 heat transfer sample from the third test in TF-3 has been completed. The sample had been exposed to 580 F water for 1584 hours at a heat flux of 280,000 Btu/hr-ft² and a pH of 10.0 using LiOH. Incipient boiling conditions were maintained with a Zr-2 surface temperature estimated at 637 F. Little hydriding was observed and the amount present was comparable to as-received material. No apparent zones of hydrides existed, indicating little if any migration had occurred. Internal Zr-2 temperatures are estimated at 800 F. In a region of reduced diameter, cracks had formed in the Zr-2 surface.

Corrosion of Materials in NPR Graphite Cooling Water System. A test to determine the corrosion rate and crud release rate of A212 carbon steel and 304 stainless steel in simulated NPR graphite cooling system water is continuing. Total accumulated exposure is 1850 hours. The carbon steel corrosion rate is less than 0.05 mil/year and the stainless steel corrosion rate is negligible. Crud release does not appear to be a problem.

Single-Step Decontaminant for NPR Carbon Steel System. Extensive testing of the proprietary bisulfate base material as a one-step decontaminant for carbon steel has been completed. This material effectively decontaminated carbon steel samples but was excessively corrosive to carbon steel. Insulated samples of carbon steel were corroded approximately uniformly a total of 2.3 mils during a 60-minute exposure in a 2.5% solution at 90 C. Severe crevice corrosion was apparent at support contact points. These results were quite at variance with results reported by the manufacturer. This was discussed with the manufacturer's representatives, and samples were given to them for additional testing.

Structural Materials Development

Burst Tests of NPR and KER Tubing. Burst tests at three temperatures have been completed on four types of NPR process tubing and one of KER. Results are tabulated below. Each entry is the average of three tests.

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Type	Cold Work	Vendor	Ultimate Hoop Stress (psi)			Circumferential Elongation (%)		
			Room Temp.	150 C	300 C	Room Temp	150C	300C
NPR	15	Harvey Aluminum	105,700	80,400	62,400	17.4	30.2	32.7
NPR	18	Chase Brass	106,300	78,300	61,300	16.8	28.1	20.8
NPR	30	Harvey Aluminum	109,000	82,100	63,500	21.1	34.2	36.3
NPR	35	Allegheny-Ludlum	115,300	83,700	65,500	5.8	23.1	19.5
KER	30	Harvey Aluminum	116,200	84,400	67,000	10.8	21.1	12.4

Although the total spread in hoop strength at a given temperature for the NPR material is not great, it shows for the most part a consistent increase with increasing cold work. The strength of the KER tubing is significantly higher than might be expected on the basis of cold work. At the same time its creep rate, as reported last month, is about four times higher than that of the NPR material. Whether this anomalous behavior is the result of differences in geometry or in structure and fabrication history is yet to be determined.

Ductility of the NPR tubing fabricated by Harvey Aluminum Company is markedly superior, particularly at higher temperatures. Reasons for this behavior as well as its possible effect on brittle fracture characteristics will be the subject of future investigation.

Prototype Irradiated Burst Vessel. The vessel was returned to the vendor and coded in compliance with Section VIII of the ASME Pressure Vessel Code for an internal pressure of 200 psig. The vessel was then returned to Hanford and has been installed in the 327 Building Wet Storage Basin.

One non-irradiated piece of cold worked PRTR tubing was successfully burst in the facility. The conditions of the test were:

Maximum Pressure	6080 psi
Burst Pressure	5840 psi
Temperature	300 C.

The internal pressure build-up in the vessel after the sample ruptured was measured to be 38 psig.

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Graphite Studies

Stored Energy. The total stored energy in graphite samples irradiated to 10,500 Mwd/At (9.2×10^{20} nvt, $E > 0.18$ Mev) in Hanford cooled test holes was redetermined at 670 cal/gm rather than 650 cal/gm reported previously. A computational error had produced the earlier result. Because of this change, it appears that the total stored energy has not yet fully saturated.

The results from two series of samples, which were exposed in the cooled test holes and then given five-minute anneals at various selected temperatures, were also received from N.B.S. These results substantiate previous data which indicate that the stored energy releasable may exceed the specific heat of the graphite in the approximate interval 1200-1600 C.

NPR Graphite Irradiations. The status of the two capsules, H-4-2 and H-6-1, of the series of long-term irradiations of NPR graphite is unchanged from last month. Due to maintenance problems the General Electric Test Reactor is having an extended outage prior to Cycle 36. At the end of the cycle, H-6-1 will be removed from the reactor.

Construction of the second of the second-generation capsules, H-5-2, is complete and the capsule is awaiting shipment. It will be installed in the D-7 position of the GETR during the first week in September. It is scheduled for an irradiation period of five reactor cycles.

Thermal Hydraulic Studies

Visual Studies of the Effects of Fuel Supports on Boiling. Laboratory experiments were continued in the study of heat transfer conditions as affected by devices used to center fuel elements in the process tubes of the Hanford production reactors. The test section for the latest experiments consisted of a 1.340-inch OD electrically heated tube placed inside of a 1.504-inch ID glass tube with the water coolant flowing in the annulus between the two tubes. The electrically heated tube had different types of fuel centering devices attached to the heated surface. These represented the supports for fuel elements in an overbore tube for C-Reactor, a "suitcase handle bumper" for BDF reactor, an elliptical-shaped bumper for BDF reactor, and an aluminum oxide support often used for electrical insulation on test sections in the heat transfer laboratory.

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The experiments were run at flow conditions corresponding to those in the flow annuli of central zone tubes (32.4 gpm) and fringe zone tubes (18.6 gpm). Visual examination and high speed motion pictures were made of the test section while the heat generation was gradually increased. The following is a summary of the data.

Run No.	Conditions	Heat Flux Btu/hr-sq ft	Comments
28	Central zone, coaxial placement, "C" overbore self supports.	455,000 and 700,000	No boiling visible.
29	Fringe zone, coaxial placement, "C" overbore self supports.	206,000 318,000 and 452,000	No boiling visible.
30	Fringe zone, coaxial placement, "C" overbore self supports and "BDF suitcase handle bumpers" both in field of view.	444,000 and 788,000	No boiling visible. A few small bubbles issued from under downstream end of the BDF bumper.
31	Fringe zone, coaxial placement, BDF elliptical bumpers and aluminum oxide supports both in field of view.	204,000 311,000 and 610,000	A few small bubbles issued from under center of elliptical bumper. Some bubbles originated on surface.
32	Central zone, coaxial placement, BDF elliptical bumpers and aluminum oxide supports both in field of view.	455,000 and 660,000	No boiling visible.
33	Fringe zone, "BDF suitcase handle bumpers" touching glass tube (0.040-inch annulus).	204,000 and 301,000	No visual evidence of boiling at bumper but large amount of small bubbles originated on test section surface.

From these experiments it can be concluded that little boiling is initiated on fuel elements due to the centering devices when the fuel is centered coaxially within the process tube. Additional tests with eccentrically located heater tubes are planned.

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Hydraulic Tests. A nine-tube segment of an 11-foot long titanium tube bundle used in liquid waste evaporators was examined for vibration in simulated operation to determine if the tubes would strike one another. Vibration measurements with the bundle submerged in water and air bubbled past the tubes showed a frequency of about 10 cycles per second with a maximum amplitude of ± 0.044 -inch compared to a tube separation of 0.125-inch. Vibration measurements have not been completed for the bundle heated with steam but initial measurements indicate vibration frequencies of 10-12 cycles per second with maximum amplitudes of ± 0.040 -inch.

Boiling Burnout Data. Burnout data obtained at Hanford using 0.444-inch ID internally cooled heater tubes were compared with similar data obtained by GE-APED (GEAP-3843) using 1/2-inch OD externally cooled heater rods. Agreement between the two sets of data was very good.

The Hanford data were obtained with horizontal test sections of 30 and 60-inch lengths and with 144-inch long test sections with both vertical and horizontal orientation. Data in both the subcooled and quality regions were obtained. Mass velocities ranged from 5×10^5 lb/hr-sq ft to 7×10^6 lb/hr-sq ft, at pressures of 1015 psia and 1515 psia.

The APED experiments were conducted with vertical test sections of 29 and 36-inch lengths. Burnouts were obtained in the subcooled and quality regions, at mass velocities ranging from 5×10^5 lb/hr-sq ft to 6×10^6 lb/hr-sq ft, and at pressures of 1000 and 1400 psia.

Comparisons were made by plotting burnout heat flux versus coolant enthalpy for each pressure and mass velocity. In cases where duplicate experimental conditions were obtained at the two sites, agreement between the data was excellent. In other cases, where the experimental conditions were not duplicated exactly, the data from APED appeared to fit very well with an extrapolation of the HAPO data.

B. WEAPONS - 3000 PROGRAM

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

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C. REACTOR DEVELOPMENT - 4000 PROGRAM1. PLUTONIUM RECYCLE PROGRAMPlutonium Fuels Development

Irradiation of Special Elements in the PRTR. Early in the month a swage compacted MgO-PuO₂ 19-rod cluster fuel element failed shortly after fuel charging and reactor startup. Later, after an exposure of about 9 MWD, the element was discharged due to excessive coolant activity. During this time, it was subjected to several thermal cycles.

The ruptured rod was located and removed from the cluster in the fuel discharge pit and sent to Radiometallurgy for a detailed examination. A longitudinal split was found on the outside of one of the outer rods in the cluster about 36 inches from the top. The split was about one and one-half inches long and had opened up about one-fourth inch at the widest point. The Zircaloy cladding had swelled nonuniformly for about four inches on each side of the split. Measurements indicate that about two inches of fuel are missing below the failure point (upstream end) and about six inches of fuel has washed out above the split in the cladding (downstream end). A total of about 9.5 inches of core material which contained about 1.8 gms of plutonium has escaped from the fuel rod. The maximum calculated core temperature for this fuel element operating in the PRTR was about 900 C so that no appreciable in-reactor sintering was expected to occur. Examination of the element is continuing.

UO₂-PuO₂ Capsule Tests. The capsule (GEH-14-85) containing high density UO₂ - 2.57 mole percent PuO₂ was discharged from the MTR. Estimated exposure is 3×10^{20} fissions/cm³ or 10,000 MWD/T of UO₂-PuO₂. Capsules GEH-14-85 and 86 were returned to Hanford for radiometallurgical examination. The latter capsule contains high density UO₂ - 4.13 mole percent PuO₂ and has an estimated average exposure of 1.7×10^{20} fissions/cm³ or 5600 MWD/T of UO₂-PuO₂.

A paper, HW-SA-2675, summarizing the work to date on the irradiation testing of 24 UO₂-PuO₂ capsules has been accepted for presentation at the ANS Winter Meeting in November 1962.

UO₂-PuO₂ Prototype Irradiation Testing. Examination of the 42-inch long cosine enriched UO₂-PuO₂ seven-rod cluster is continuing in Radiometallurgy. More transverse and longitudinal sections of the fuel rods have been made through regions of high PuO₂ concentration.

Central voids and columnar grains have formed in some areas which had the most severe PuO₂ segregation. The fuel rods were vertical during irradiation and the voids which have formed appear to be displaced toward the top of hot spots. Dark spots on the external surfaces of the irradiated fuel rods are definitely associated with regions of high PuO₂ concentration and result from localized areas of abnormally high surface heat fluxes.

Phoenix Experiment. The irradiation and reactivity measurements on the high-exposure aluminum-plutonium samples are continuing in the MTR and ARMF. All three samples have now received five cycles of irradiation in the MTR. A reactivity transient measurement will be made with the sample which contains plutonium with initially 16.33 percent Pu-240 immediately following its sixth cycle of irradiation.

MgO-PuO₂ and ZrO₂-PuO₂ Irradiation Capsules. Eight Zircaloy-clad capsules (one-half-inch diameter x 4 inches long) containing ZrO₂-PuO₂ fuel pellets and eight containing MgO-PuO₂ pellets have completed their irradiation in the ETR. ZrO₂ - 2.18 w/o PuO₂ and 10.39 w/o PuO₂ pellets as well as MgO - 3.09 w/o PuO₂ and 13.52 w/o PuO₂ pellets were irradiated at different core temperatures for different periods of time. Calculated maximum core temperatures for the ZrO₂-PuO₂ samples were 1600 and 2800 C and maximum temperatures for the MgO-PuO₂ specimens were calculated to be 1700 and 2200 C. Four of the irradiated MgO-PuO₂ samples are being examined. Transverse sections of the samples show that general cracking has occurred in the specimens which operated at the lower temperatures whereas center voids and columnar grains have formed in the samples which operated at the higher temperatures.

A cursory examination of the ZrO₂-PuO₂ specimens showed that discolored areas indicative of hot spots were present on the surface of some of the samples. The cladding on one of the capsules that contained ZrO₂-10.39 w/o PuO₂ pellets which operated at the highest power generation to the highest burnup has failed even though there were no rupture indications during operation in the ETR. Two longitudinal cracks about one-half inch long and one-fourth inch apart have opened up at one end of the capsule. The capsule has not swelled appreciably suggesting a brittle type failure. The sample will be examined in an effort to determine the cause of failure.

Extended Surface Plutonium Fuels. In a scale-up experiment, a thirty-gram plutonium-zirconium alloy core was roll-clad with zirconium; previous plates contained ten-gram plutonium cores. The bare plutonium-zirconium core was assembled in the zirconium picture frame, the steel sandwich welded shut, cold-rolled to compact the

sandwich, and hot-rolled. The finished plate was well bonded; however, wide spread alpha contamination existed on the plate surfaces. The contamination was readily removed by etching except on the edge where an alpha count of 5000 d/m existed. The contamination was non-smearable but apparently rather general throughout the bond zone since it occurred in many locations and was not removed by abrading. Further decontamination techniques are being tried on this piece. In addition, coating techniques will be tried on the core material in order to prevent contamination in the first place. It is planned to try copper and nickel plating and tin or zirconium foil wrappings. Aluminum foil wrapping previously used was successful in preventing contamination to the outside of the plate, but the aluminum apparently added to the formation of intermetallic compounds in the plutonium-zirconium core which in turn caused wide variations in the core thickness.

Fabrication of High Exposure Aluminum-Plutonium Fuel for Physics Experiments. Aluminum-plutonium fuel rods containing high-240 plutonium are being fabricated for use in the Physical Constants Test Reactor. Alloy core rods were extruded about a year ago and are now being loaded into Zircaloy sheath tubes. The fabrication is about 50 percent complete.

One thousand high exposure aluminum-plutonium rods for the light water critical experiment are also being fabricated. One hundred and ten Al-2 w/o Pu billets have been cast for extrusion and Zircaloy canning components are being machined.

Uranium Fuels Development

Thermocoupled Fuel Element. A thermocoupled fuel element was assembled and delivered to PRTR for measurement of fuel temperatures at several positions within the element during operation. The 19-rod cluster contains six thermocoupled, fused UO₂ fuel rods, two of which were fabricated by cold swaging, two by hot swaging, and two by vibrational compaction.

Reinforced, Large Diameter Fuel Element Cladding. It has been shown that an empty four-inch length of 2.328-inch OD x 0.060-inch wall Zr-2 tubing with end caps welded in place will collapse explosively when subjected to 1100 psi at 400 C. However, the same cladding will not collapse under these conditions when connected by five equally spaced ribs to a 3.068 x 0.060-inch wall Zr-2 outer tube. The latter arrangement allows the fuel tube to resist collapse until a pressure of 1500 psig at 400 C is reached. In addition to acting as a fuel cladding strengthener, the outer tube may possibly be used as a disposable process tube.

Remote Fabrication Studies. Closed circuit television equipment was received and operated successfully. Calibration and zoom lens focusing were completed with one camera and are nearing completion with the second camera. Lighting effects are being studied. The associated remote manipulator system for fuel handling was ordered; delivery is scheduled for December.

Thermal Hydraulic Studies

Shutdown Cooling of the PRTR. Studies were made to evaluate methods of cooling fuel in the PRTR during a total power outage. In such a case power to the primary coolant circulating pumps would be lost and some alternate method of removing heat from the reactor would be necessary.

Theoretical calculations performed in the past have indicated that, following scram, natural convection of the primary coolant would be adequate to carry fission product decay heat from the fuel to the steam generator without any boiling in the primary system. However, there has been some reluctance to depend on this method until the theoretical adequacy is verified by experimentation.

In an effort to get a more accurate knowledge of flow during natural convection, results of PRTR primary system low-flow tests were examined. During a recent outage pressure drops were measured by members of Test Reactor and Auxiliary Operation for flow rates in the range expected for natural convection. Results of these experiments were compared with theoretical pressure drops calculated during previous natural convection studies. The comparison indicated that, for a given natural convective head, the experimental flow rates were substantially less than the theoretical values (on the order of one-half as great). Detailed descriptions of the test procedure, experimental setup, and experimental data are being examined in an effort to resolve the discrepancy between the theoretical and experimental values.

The experimental data indicate that during a total power outage the flow rate would probably be insufficient to prevent boiling in the primary system. In such a case, however, it is expected that boiling would provide adequate cooling as long as fuel elements are covered with water.

An alternative method, which has been given some consideration, is cooling the reactor by once-through circulation of light water. This would be accomplished by opening a two-inch vent valve on the pressurizer and depressurizing the primary system so that water

could be supplied by the 100 psi head diesel well pump. Water from the well pump would flow through the reactor, to the pressurizer, and out the vent valve. Two basic questions were raised in investigating the adequacy of such a procedure: (1) how long would it take to depressurize the system to the point that water could be supplied by the well pump, and (2) what liquid flow rates could be provided after depressurization with flow being restricted by the vent valve? Calculations were performed showing that once liquid flow was established in the vent valve the flow rates would be more than adequate to remove heat generated in the fuel elements. (Flow rates range from 150 gpm for a 10 psi pressure drop across the valve to about 475 gpm for a 100 psi pressure drop, with 100 to 200 gpm being adequate to remove the heat.) However, the calculated time from initiation of blowdown to the time the system pressure would reach 100 psi, and light water injection could begin, was in excess of 15 minutes; the blowdown being restricted by steam flashing in the vent valve. During this time water would be flashing to steam throughout the primary system. It is impossible to say just how well fuel elements would be cooled during this period. If this procedure is to be used for cooling during a total power outage, it would be desirable to provide either a higher pressure injection pump or additional venting capacity to allow more rapid blowdown.

Thermal Hydraulic Analysis of the PRTR. A re-examination was made of the thermal hydraulic analysis of the PRTR and its fuel elements with particular emphasis placed on increasing the allowable power. Results of experiments with electrically heat test sections were combined with analytical calculation to examine boiling burnout and hydraulic stability conditions for both the Mk I (a 19-rod bundle fuel element) and the Mk II-c (a nested tubular fuel element consisting of two tubes and a center rod).

It was concluded that the allowable tube power could be increased from 1200 KW to 1800 KW if the inlet temperature would be decreased sufficiently to prevent bulk boiling at the tube outlet. It was also concluded that the maximum heat flux could be increased from 400,000 to about 750,000 Btu/hr-sq ft without violating a 1.85 boiling burnout safety factor proposed for the PRTR. A document discussing the thermal hydraulics aspects of the increased power generation and heat flux in PRTR is being prepared.

Component Testing and Equipment Development

Mechanical Shim Rod. Detail design of the second generation mechanical shim rod assembly is approximately 70 percent completed.

Liquid Shim Control. Development work on the liquid second generation shim control for the PRTR has been indefinitely postponed because of insufficient funding.

Shim Rod Environment Control Test Facility. A shortage of craft personnel and higher priority work limited progress on the installation of the shim rod environmental test facility.

EDEL-I Renovation. Installation of the new temperature monitoring system for the EDEL-I loop has been completed and checked out. Installation of electrical wiring, controls, and the new safety circuit is 85 percent completed. All raw water interties and galvanized pipe are being removed from the deionized water system in order to maintain high water quality and good deionizer resin life. The new system will be fabricated from 300 series stainless steel and supplied with steam condensate instead of raw water. All design work is complete and materials are either received or are on order to install a feed and bleed system for pressure control to replace the feed-bleed-steam pressurizer control system previously used.

Fretting Corrosion Investigation. Investigation of equipment and test procedures to detect relative motion of a fuel element in a PRTR pressure tube mounted in the EDEL-I loop continued. Consultation with Operations Research and Synthesis Operation on test procedures indicates that an effective program of investigation of the in-reactor variables on fuel element-process tube motion can be readily designed. Proper instrumentation should enable the effect of these variables to be quickly measured. However, it will be necessary to correlate the relative motions of the fuel element and pressure tube components to the actual problem of tube fretting with longer term tests.

An eddy current technique to measure the relative motions of a PRTR fuel element and a process tube was bench tested. Stationary inductive coils inside fuel rod tubes were excited with a 100 KC alternating current source. Displacement sensitivity of 12 millivolts per mil of tube movement was obtained. Although the results show the technique to be suitable, further work to determine environmental effects, such as operating temperature, are required.

Review of fuel element fabrication methods to accommodate eddy current inductive coils in fuel rods has revealed no serious difficulties.

Shroud Tube Replacement Mockup. Work on the mockup pit was re-initiated on the first of the month and the pit excavation and liner installation has progressed to the minus 22-foot level. The pit will eventually be 32 feet deep. Fabrication of the mockup crates simulating a portion of the top and bottom primary shields and the calandria, and design of special tools for shroud tube replacement, has been stopped pending availability of funds. Design effort had progressed to the complete detail design of a cut-off tool for removing the shroud tube-top bellows weld and to the layout of a tool for removing the shroud tube-bottom tube sheet weld.

Inlet Bellows to Pressure Tube Gas Seal. No additional testing or developmental work was performed on the PRTR inlet bellows to pressure tube gas seal. It was agreed with Maintenance and Equipment Engineering Operation of TRA0 that only limited additional development effort was justified to find an alternate seal which is cheaper to fabricate than the B-F Zircaloy ferrule seal, which has proven satisfactory in laboratory leak rate tests.

Outlet Nozzle to Top Shield Gas Seal. Highly compressible metallic gaskets of special design have been received for testing. These gaskets proved to be too thick for the present nozzle-centering flange arrangement, as they prevent engagement of the nozzle flange with the torque lugs on the centering flange, which prevents the nozzle from turning. They may be tested with the new nozzle hold-down arrangement which does not use the existing torque lugs.

Hazards Analysis

Reactor kinetics studies were continued of a uniformly enriched PRTR core consisting entirely of mixed crystal, $\text{UO}_2\text{-PuO}_2$, fuel elements. All of the analog studies for the 0.75 w/o plutonium enrichment level were completed. These studies indicate that the uniformly enriched mixed crystal, $\text{UO}_2\text{-PuO}_2$, core can be operated as safely as the initial spike enrichment core containing natural UO_2 fuel elements and plutonium-aluminum spike enrichment fuel elements.

Pressure equalization between the process cell and the reactor hall following the occurrence of a large leak in the PRTR primary coolant system was analyzed. Two paths exist for pressure equalization, the pressure relief doors on the steam generator enclosure which open at a differential pressure of 4 psi and the two doors from the process cell to "C" cell stairway. Considering only the

100 square foot pressure relief doors on the steam generator enclosure for pressure equalization, the pressure difference between the process cell and the reactor hall would increase rapidly until the pressure relief doors would open at 4 psi and then drop to about 0.2 psi after the doors opened. Shielding blocks in the process cell and "B" cell ceiling are bolted down to withstand a 15 psi differential pressure. The cover blocks on the fuel examination facility would be lifted by a pressure in the facility 5.7 psi greater than the pressure in the reactor hall, but this pressure differential is not expected to occur.

Plutonium Recycle Critical Facility

Hazards Analysis. Analog studies of PRCF core configurations with 100, 80, 60 and 35 percent of the fissions occurring in plutonium were completed. For these various core configurations excursions were initiated for two cases - with the reactor assumed to be sub-critical and with the reactor operating at 100 watts power level. All analog studies terminated by reactor scram showed no measurable fuel temperature increase. Studies of the all-plutonium loadings terminated by steam formation in the moderator indicated no fuel element melting would occur at the peak of the excursion.

Preparation of comment issues of the PRCF Process Specifications is approximately 90 percent completed. Preparation of the final drafts for approval is about 15 percent completed.

PRTR Rupture Loop

Component Testing and Equipment Development. Thermal cycling and stress tests on the Grayloc connector were delayed pending delivery of the new EDEL-2 circulating pump shaft.

Essentially all components, special tools, and equipment for discharging rupture loop fuel elements assigned to EDC have been completed. An operational test of this equipment was conducted during August. A simulated discharge of the pressure tube was performed to the point of having the tube assembly ready for discharge into the PRTR Fueling Vehicle. In general, performance of the over-all procedure was satisfactory. Minor difficulties were encountered; these are being corrected by improvements to the tools and/or procedures.

The present rupture loop fuel discharging procedure, which calls for discharging the rupture element and the pressure tube as an assembly, is complex and time consuming. A simpler, though

longer range approach, is a cask method which will allow discharge of only the fuel element while maintaining water cooling on the fuel element at all times. A scope design is being prepared of a cask to permit fuel discharge in this manner. It will be patterned after an ETR cask which has proven satisfactory in this type of operation.

PRTR Gas Loop

Component Testing and Equipment Development. The "as-built" work on the in-reactor test section drawings for the gas loop has revealed several additional requirements not provided for in the original design. One of these pertains to the thermocouples which monitor for bowing of the test section, specifically, how to bring them out of the reactor core. The possibility of bringing these couples through the top centering flange is being investigated. A second requirement, for frequent examination of the inside surface of the test section pressure tube, necessitates the removal of an inner tube which acts as a thermal barrier. The present inner tube fits too tightly to be easily removed. As a result, the inner liner is being redesigned for easy removal.

The sample container cask for the gas loop is being evaluated for operability. Design of shipping cradles for the sample casks is under way, and the design of a new sample holder installation and removal tool has been completed.

Materials Development

Effect of Vacuum Dissolution of Autoclaved ZrO_2 Films on the Corrosion of Zircaloy-2 and Crystal Bar Zirconium. Preliminary data from a series of heat treatments on 20 mg/dm^2 oxide films on crystal bar zirconium indicate behavior similar to that observed previously on Zircaloy-2. Vacuum heating at 600 C for times up to 20 minutes caused no increase in the normal corrosion rate. Heating for 60 minutes at 600 C increased the oxidation rate appreciably (40 mg/dm^2 after three days compared to 20 mg/dm^2 for untreated specimens).

In-Reactor PRTR Pressure Tube Monitoring. Renovation of the present equipment for visually inspecting and measuring fretting mark depths in the PRTR process tubes is about 80 percent complete. Only machining of the borescope shroud tube and final assembly remains to be done. The new ruggedized dial gage for measuring the depths of fretting marks has been fabricated and preliminary testing completed. Final testing is awaiting completion of the borescope

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shroud tube. The renovated equipment is sized to permit inspection of the PRTR rupture loop and gas loop tubes. A letter outlining the proposed monitoring programs for the two loops has been sent to PRTR Operations.

The Mark III in-reactor monitoring equipment which combines the two present probes for visual and instrument inspections is 85 percent complete. The Omniscope objective section has been returned from the vendor after having the lenses recemented. The lenses separated when overheated by the borescope lights. A temperature actuated switch on the light power supply has been added to prevent a recurrence of the overheating. Provisions for air cooling the lamp base also will be incorporated in the design of a new light mount and depth gage assembly. Fabrication of the inspection probe rotating device is complete. Limit switches have been added to give full probe rotation without over-travel. Readout equipment for remotely indicating the depth of the probe in the pressure tube and the angle of probe rotation has been installed on the control console. The gas gap probe has been assembled, and calibration has been started. Functional testing of the X-Y recorder for continuous plotting of pressure tube inside diameters has begun. Problems with feedback of the Y signal onto the X axis have been encountered and are under investigation.

Post-Irradiation PRTR Pressure Tube Evaluation. Metallographic examination of the 24-mil upper fuel element bracket corrosion mark from process tube 5540 (channel 1356) showed no indication of an increase in hydrogen content. Of the 21 corrosion marks examined, only three have had a layer of hydride concentrated just below the mark. In two other cases there was an indication of a slight increase in the number of hydride platelets in the metal beneath the marks. In no case has hydriding been found under marks deeper than six mils.

Decontamination of PRTR Components. Some components removed from PRTR were sent to 1706-KE for decontamination prior to examination. The standard procedure (APACE) was not effective. Even after several cycles, the activity levels were not decreased sufficiently. The activity could be removed by a combination of mechanical and chemical treatments, but straight chemical treatments did little good.

Some coupons were prepared from one of the components (lower ring header jumper) and were treated in several decontaminating solutions to determine an effective process. Two-step procedures were used.

alkaline permanganate followed by some inhibited acid or acid salt. The two-step procedures using bisulfate, nitric acid, ammonium citrate, or phosphoric acid were all ineffective. A two-step procedure utilizing an oxalic acid compound as the second step was effective, giving a decontamination factor of ~ 150 . In all cases, when the decontamination factors were low, the film was not removed.

Fretting Corrosion of Zircaloy. The hydraulic vibrator used to induce vibration on a PRTR fuel element for a fretting test in TF-7 was replaced with an air-operated vibrator when the hydraulic vibrator failed to function properly even after it had been checked at the factory. The air-operated vibrator induces a circular type vibration by means of a hardened ball revolving in a circular race-way. The PRTR fuel element was vibrated one week at 80-100 cycles/second, and then examined. Wear of less than one mil deep and approximately $\frac{1}{2}$ " x $\frac{1}{2}$ " in area was found on the process tube where the loose end of the cut wire wrapping of the fuel element came in contact. No other wear was observed. This test is being run in pH 4.5 water at 300 C. At the next shutdown period the pH will be returned to 10.0 to more closely duplicate PRTR conditions.

2. PLUTONIUM UTILIZATION STUDIES

Plutonium Oxides

Electrical resistivity measurements have been made on samples of C/Pu ratios 1.84, 1.92 and 1.96. The eutectoid reaction at 280 C was not detected; however, the temperature limit for the solid immiscibility region was readily observed. The single face centered cubic phase existing above this region had an electronic activation energy of 0.50 ± 0.02 eV. The activation energy in this region varied directly with O/Pu ratio, as did the room temperature resistivity.

Thermal emf measurements at high temperature have been initiated. Some problems have been encountered with maintaining vacuum to prevent oxidation. It has been definitely shown that the sign and magnitude of the voltage generated change when oxidation occurs.

The p-type conductivity of PuO_{2-x} is now believed to be due to the alpha Pu_2O_3 which coexists with PuO_2 at room temperature over the composition range of O/Pu of 1.62 to 1.98.

Dilatometer experiments on $\text{PuO}_{1.91}$ and $\text{PuO}_{1.84}$ have shown the hysteresis characteristic of the reduced oxides at 300 and 650 C.

Expansion coefficients for PuO_{2-x} compositions are presently being calculated. A least squares fit applied to high temperature x-ray diffraction data has shown that the expansion of $\text{PuO}_{2.00}$ can be represented by a second order polynomial. The program has been resubmitted to the IBM-7090 to calculate coefficients for the interval 24-1275 C. The earlier coefficients covered a temperature range of 24-1620 C and were slightly in error due to an oxygen loss from the sample above 1275. These data will be reported shortly in HW-74788.

Several samples with O/Pu ratios of 1.77, 1.80, 1.85 and 1.86 were heated to 600 C, held there for several days, and then cooled to room temperature at a rate of 5-10 C per hour. Resultant x-ray powder patterns showed, for each sample, a two-phase mixture of body centered cubic (BCC) $\alpha\text{-Pu}_2\text{O}_3$ and face centered cubic (FCC) PuO_2 . The latter-phase may be slightly oxygen-deficient to the extent of approximately $\text{PuO}_{1.98}$.

Based on resistivity, thermal expansion, x-ray diffraction, and thermal emf experiments, a phase diagram has been constructed for the Pu-O system. The essential features are a eutectoid reaction at $\text{PuO}_{1.70}$ and 300 C between $\text{PuO}_{1.62}$ and $\text{PuO}_{1.98}$; the existence of a two-phase loop between 300 and 650 C and from $\text{PuO}_{1.70}$ to $\text{PuO}_{1.98}$; and the existence of a single-phase region above 650 C. This region is cubic and possesses an oxygen-deficient fluorite structure. A melting minimum is shown at 2280 and about $\text{PuO}_{1.65}$. $\text{PuO}_{1.62}$, previously referred to as $\alpha\text{-Pu}_2\text{O}_3$, has been found to melt congruently at 2400 C. This phase exhibits an allotropic transformation below 800 C. The phase relations below $\text{PuO}_{1.5}$ are a coexistence of beta Pu_2O_3 and plutonium metal. PuO appears extremely unstable and could not be formed by reacting Pu and Pu_2O_3 . This phase diagram will be published shortly.

PuO₂ Compatibility Tests

Samples of PuO_2 powder and metal powder, each 50 mole percent, were mixed and pressed for firing at about 1700 C for two hours in a helium atmosphere. Subsequent x-ray powder patterns indicated very slight reaction for a PuO_2 -molybdenum mixture, some observable reaction for a PuO_2 -tungsten mixture, and apparently complete reaction for a PuO_2 -tantalum mixture. The powder pattern for the PuO_2 -tantalum mixture revealed no observable tantalum lines after sintering.

PuO₂ - Carbon Reactions

Three samples of PuO₂ powder and graphite powder were mixed and pressed with pellets for attempts at preparing beta-Pu₂O₃, PuO and PuC. After being held at 1800 C for five and one-half hours in a helium atmosphere, x-ray powder patterns revealed, respectively, 100 percent beta-Pu₂O₃, a mixture of about three as yet unidentified phases, and approximately 95 percent PuC and five percent Pu₂O₃. The melting point of the beta-Pu₂O₃ was observed to be about 2090 C.

Plutonium Carbides

A series of Pu-C alloys covering the region of 12 - 52 a/o C has been annealed at 600 C for 124 hours in vacuum followed by an eight-hour cool to room temperature. X-ray diffraction examination indicated a slight increase in lattice constant of the PuC

greater than 41 a/o C. A large difference in quality of the diffraction spectra above and below 41 a/o C was noted. Above 41 a/o C the PuC phase gave a very clear pattern with well resolved high angle doublets. Below this composition, there were several diffuse unindexed lines and the PuC doublets were blurred and unresolvable. This is presumably due to the formation of the zeta phase. Metallography has indicated the presence of a needle-like growth between the PuC grains and the alpha plutonium phase. Microhardness determinations have shown a large increase at 40 a/o C. The hardness of the PuC phase above 40 a/o C appears to be proportional to carbon content.

Another anneal was performed on a series of plutonium-carbon alloys. In this experiment the samples were held at 600 C for 168 hours and cooled to room temperature at the rate of 0.13 C/min. The purpose was to cool extremely slowly through the 575 C peritectoid and achieve true equilibrium with respect to the zeta phase. X-ray powder patterns have again indicated a good crystalline PuC phase above 41 a/o C. Below this composition the patterns were blurred and gave many weak and diffuse lines which were unindexed. Some line positions and intensities were close to that of PuC, and it is apparent that the zeta phase exhibits a disorganized lattice.

temperature range 26 - 800 C. Measurements at higher temperatures were prevented by oxidation of PuN at 1×10^{-4} mm Hg, air. The linear equation which best fits the lattice data was determined by the method of least squares. The average coefficient of linear thermal expansion calculated from this equation is $13.80 \times 10^{-6}/^{\circ}\text{C}$.

Microhardness data were obtained on dendritic PuN formed by arc-melting plutonium under one atmosphere of nitrogen. The surface of the specimen was electropolished in a tetrakisphosphoric acid solution prior to testing. A Vickers 136 degree diamond pyramid indentation was used with a 200-gram load. Photomicrographs show cracking at each indentation, thus clearly displaying the brittle nature of PuN. The average diamond pyramid hardness number, DPH, computed from the best indentations is 370 Kg mm^{-2} .

3. UO₂ FUELS RESEARCH

UO₂ Melting Studies

Motion pictures of UO₂ melting under argon pressures up to 1500 psi were taken through a microscope at 25X magnification. These show graphically the effect of pressure in suppressing vaporization from both molten and solid UO₂.

Graphite Welding

There is interest in using graphite cans for fuel elements operating in high temperature gas-cooled reactors. Brazing, gluing and mechanical seals have been used at various sites to make closures, but there has been little, if any, success in welding graphite.

Preliminary experiments have shown that a graphite cap and tube can be successfully welded together using magnetic force welding techniques. However, with the existing setup, full machine capacity is needed to obtain graphite bonding. This indicates that a percussive welding technique would be best for graphite.

Irradiation of Swaged UO₂

It was previously reported that two swaged UO₂ fuel capsules, GEH-14-177 and GEH-3-52, were discharged from the reactor after attaining exposures of 37,000 and 53,000 MWD/T_j, respectively. Extensive post-irradiation examination, including improved mass spectrometric burnup analyses, indicates that the original exposure estimates were in error; revised performance data for these capsules are shown in the accompanying table.

Irradiation Data for
High Exposure Swaged UO₂ Capsules

	<u>GEH-14-177</u>	<u>GEH-3-52</u>
Cladding OD, inch	0.565	0.700
Cladding Thickness, inch	0.030	0.050
Max. Surface Heat Flux, Btu/hr-ft ²	0.4 x 10 ⁶	0.4 x 10 ⁶
Exposure, MWD/T _y	14,200	23,200
Fission Gas Release, percent of total formed	32.9	81.5
Xe/Kr ratio	9.95	9.57

High Rate Densification of UO₂

Tungsten carbide dies being evaluated in the Dynapak machine for high rate densification of UO₂ were used repeatedly at impact pressures of 350,000-400,000 psi without failing. At impact pressures in excess of 350,000 psi, micronized UO₂ in evacuated cans at 1100-1200 C was densified to greater than 10.86 g/cc (99 percent TD). Oxygen/uranium ratio of the compacted UO₂ was in the range 2.03-2.04. Hydrogen treatment at 1000 C reduced the O/U ratio to < 2.01. High temperature treatment at 1750 C in hydrogen did not cause bloating of the UO₂, which indicates that evacuating air from the cans before compacting prevents entrapment of gas in the UO₂.

Irradiation of UO₂ Containing Tungsten Marker Wires

Post-irradiation examination of a UO₂ fuel capsule (GEH-4-72) which originally contained small tungsten wires in a spiral array tends to confirm the hypothesis that the high density annular region often observed in irradiated fuel elements represents the radial limit of initial melting. Examination of transverse cross-sections of the 1.44-inch OD fuel element revealed that the 0.014-inch diameter by 1/4-inch long tungsten wires originally present in the central (predicted molten) region of the fuel are no longer present; probably because they sank in the molten UO₂. Ceramographic examination of this fuel capsule is continuing. A 75X photomosaic of the entire fuel cross-section was obtained to facilitate the study.

Photomosaics of Fuel Elements

Interpretation of phenomena such as void migration, fuel relocation and microstructural changes in irradiated UO₂ fuels has been

greatly facilitated by detailed examination of large photomosaic reproductions of sections of irradiated fuel elements. However, comparisons with similar representations of unirradiated fuel have been needed to assist in correlating particle size distribution and fuel quality with effects observed in irradiated specimens. To this end, a 75X photomosaic of a transverse section of an unirradiated vibrationally compacted, fused UO₂ fuel rod was prepared.

Thermal Conductivity of UO₂

It has been found that the high temperature thermal conductivity of UO₂ single crystals (measured at BMI for Hanford Laboratories) can be expressed as the sum of three components: Phonon conductivity (k_p), radiative conductivity (k_r), and excitation process conductivity (k_{ex})

$$k_{obs} = k_p + k_r + k_{ex}.$$

This summation can be expressed as a function of temperature (T).

$$k_{obs} = (A + B) + CT^3 + DC\frac{E}{T}$$

The constants in this expression have been evaluated from the thermal conductivity data and appear to be of reasonable magnitude.

4. BASIC SWELLING PROGRAM

Irradiation Program

Two general swelling capsules charged into a reactor last month are still under irradiation. These have operated without incident at 575 C. Two previously irradiated capsules remain in the reactor discharge basin for additional radioactive decay before shipment to Radiometallurgy for disassembly. Two previously irradiated capsules (#11 and #12) have been disassembled and the specimens recovered. These specimens do not appear to be as distorted and swollen as the specimens from capsules 7 and 8 which were discussed in the May and June reports.

The chamber on the general swelling capsule enclosing the NaK and specimens has been redesigned to enable the installation of two 1/16" heaters in lieu of the previously used 1/8" heater. The construction of the capsule employing this modification is about ten percent complete. The 1/8" heaters ordered from off-site have not been received and a delivery date is uncertain. A new specification, HW-74572, has been prepared to reorder 1/8" heaters.

Thermal cycling of the MTR prototype capsule has been completed. This capsule contained a solid cylinder of uranium, one surface of which was metallographically prepared. The specimen was thermally cycled 100 times from approximately 70 C to 600 C. Examination of this specimen is under way. Meanwhile, the capsule will be disassembled to permit removal of the heat transfer fins and installation of fins with a thicker cross-section. The thicker fins will help determine the maximum attainable temperature for this capsule with a 1/16" heater and will empirically provide needed information and corroboration of previously conducted heat transfer calculations on the characteristics of this capsule design. Two uranium samples consisting of one-half of a beta heat treated split, hollow cylinder and another half of a split, hollow cylinder in the as-extruded condition will be thermally cycled in a NaK environment in this capsule.

Post-Irradiation Examination

Two general swelling capsules, #11 and #12, were opened in Radio-metallurgy, the specimens recovered and visual examination completed. Each capsule contained six half, hollow uranium cylinders (arranged in pairs in the capsule) with a 0.030-inch wall thickness. Capsule 12 operated at a control temperature of 625 C except for a one-minute temperature excursion that went to 730 C followed by two days at 450 C. This occurred at about two-thirds of goal exposure. Capsule 11 was not controlled but operated between 400 and 450 C when the reactor was at full power and at ambient temperature when the reactor was off. The specimens from capsule 12 are in much better condition than are those in capsule 11. These two capsules were irradiated in a tandem arrangement in the same test tube to an estimated exposure of 0.16 a/o B.U. in the specimens. Two of the three specimens in each capsule were irradiated in the as-extruded condition while the third sample had been vacuum annealed at 730 C for 15 minutes followed by a quench into oil at room temperature.

The as-extruded specimen in capsule 12 that was adjacent to the control thermocouple exhibited no change in external appearance due to irradiation. The other as-extruded specimen exhibited very slight general warping and only one corner of one of the half cylinders was severely warped. The beta-quenched specimen showed distinct surface roughening ("bumping") and some general warping.

Both of the as-extruded specimens in capsule 11 were warped and directional surface roughening had occurred leading to a striated or fibrous appearance. The striations were parallel to the original extrusion direction. The beta-quenched specimen was in very poor condition as severe warping and surface bumping had occurred.

These observations leave little doubt but that "growth" or "dimensional instability" effects are still active above 400 C and probably as high as 600 C. This, of course, is contrary to the popular belief that "growth" is inoperative above about 400 C. The appearance of these specimens tends to corroborate the previous conclusions that the severe damage suffered by the specimens in capsules 7 and 8 was due to "growth" rather than to swelling.

Preliminary electron microscope examination of a portion of one of the as-extruded samples from capsule 12 shows extensive cracking and porosity ranging in size from 0.1 to 10 microns. The smaller pores are in patches surrounded by large pores. The pores do not exist preferentially at grain boundaries or any other crystallographic feature. The cracks are transgranular and are bounded with pores of all sizes suggesting that gas has not migrated into the crack. Examination of this specimen will continue and the other specimens will be metallographically processed.

Examination of replicas prepared from Zircaloy-2 clad U (enriched) - U (depleted) diffusion couples which had been annealed at 700 C for 100 hours after irradiation has been completed. Observations based on these samples are similar to those made previously from a U-U couple which had been annealed at 800 C, except that the pore sizes in general are smaller than that observed in couples annealed at 800 C. There is no conclusive indication that fission gas diffusion has occurred across the U-U interface.

Supplemental Studies

A uranium specimen that was cycled 100 times between 75 C and 600 C exhibited a great deal of surface roughening. Replicas prepared on the cathodically etched surface before and after cycling are being carefully examined and identical areas are being compared. On the basis of these observations it would appear that irradiating a uranium specimen with a precharacterized surface at an elevated temperature would require that the capsule temperature be maintained constant when the reactor was down as well as when it was up, thereby eliminating the effects of temperature cycling on the irradiation induced changes in surface topography.

Three approaches for obtaining three dimensional pore size and frequency information from electron micrographs of uranium surfaces are being pursued. The first involves choice of a functional form of the distribution, such as log-normal with adjustable parameters,

and then a determination of the two dimensional distribution analog and comparison with the experimentally determined distribution data. The second approach is to unfold the experimental distribution data to yield a three dimensional plot. This unfolding requires knowledge of where pores are cut with respect to their centers. A number of micrographs have been analyzed and apparent pore diameters and pore shadow lengths have been measured. The shadow lengths, however, require prior knowledge of the replica shadow angle which may vary from grain to grain due to etching characteristics. This variation is currently being investigated with known standard sized spheres of polystyrene which have been sprayed on the replica surface prior to shadowing. A third approach for obtaining reliable three dimensional distribution involves replotting of apparent two dimensional distribution data in terms of larger cell sizes. Previous plots were constructed on the basis of a large number of cells, each cell having an associated range of pore diameters. Plots of pore volume fraction versus cell number, where each cell now is larger and includes four of the previously used cells, have been obtained for two types of specimens (0.29 a/o and 0.41 a/c burnup) which were annealed after irradiation at various temperatures. Changes in shapes of these distribution curves are being determined.

5. IRRADIATION DAMAGE TO REACTOR METALS

Alloy Selection

An alloy whose mechanical properties indicate that it may have potential use to 1800 F is alloy R-27 which was developed by Allegheny Ludlum Steel Corporation. A cursory examination of the effects of various oxidizing environments and irradiation at high temperatures is now in progress. Two oxidation tests were completed using CO₂ at 1700 F and 1800 F. These tests indicate that the R-27 alloy withstands these conditions as well as the austenitic stainless steels. Further tests will be carried out in CO₂ at 1900 F and 2000 F.

Tensile specimens of the R-27 alloy have been prepared. Specimens in the fully annealed condition have been tested at room temperature and found to have a 0.2 percent yield strength of 51,000 psi, an ultimate tensile strength of 110,000 psi, and a uniform elongation of 52 percent. Additional specimens are being heat treated and will be tested in the double aged condition at room temperature. This aging is being accomplished by holding the specimens at 1400 F for eight hours, air cooling, followed by reheating to

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1400 F for 24 hours and air cooling. Additional specimens will be double aged by holding the specimens at 1400 F for 24 hours, air cooling, followed by reheating to 1400 F for 24 hours and air cooling. The mechanical properties of the material treated by these two methods will be compared.

Sheets of three additional alloys, Hastelloy N, Haynes R-41, and Haynes R-235, are being hot rolled in order that oxidation, corrosion and tensile specimens can be fabricated.

Hanford Laboratories is to be responsible for the procurement, storage, and disbursement of structural materials samples to be used in the Irradiation Effects on Reactor Structural Materials Program, where use of such material is by more than one participating site. Approximately eight hundred square feet of space has been acquired in the 3718 Building warehouse and plans for storage facilities have been initiated.

In-Reactor Measurement of Mechanical Properties

A series of measurements were made of the activation energies of Zircaloy-2 during neutron irradiation. These measurements confirm values previously obtained and provide thermodynamic evidence that creep rates will be lowered during neutron irradiation, substantiating observations of reduced rates during irradiation. The activation energy measurements were made in a creep capsule which had lost the front heater. The loss of the heater precluded running a constant temperature creep test. However, a portion of the specimen could be controlled at various temperatures and the creep rates at these temperatures could be measured. The activation energy measurements, as previously reported, were made using the temperature increment method. The effect of the reduced gage length of the specimen at an effective temperature is easily accounted for in the calculations since only the rates immediately before and immediately after a temperature change are being measured.

The activation energies found averaged 62,000 cal/mole between 275 C and 325 C and 86,900 cal/mole between 350 C and 375 C. These values are accurate to ± 5000 cal/mole and are in agreement with values previously reported for in-reactor creep. The high activation energy value, 86,900 cal/mole, is attributed to annealing of radiation induced defects during the temperature increment. This in turn increases the temperature dependence of creep deformation in the damage annealing range. The 62,000 cal/mole value is within experimental error of the self-diffusion activation energy for the creep of Zircaloy-2.

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The effect of radiation produced excess vacancies on the creep of metals has received considerable attention from various theoreticians. Quantitative estimates of the excess vacancy effect predicts an increased diffusion rate and, therefore, an increased dislocation climb rate of temperatures near one-half the absolute melting temperature. The increased climb rate would in turn produce an increase in creep rates. The activation energy for creep when diffusion controlled consists of two parts: the energy for vacancy motion and the energy for vacancy formation. When vacancies are being created in greater numbers by irradiation than by thermodynamic processes, only the activation for vacancy motion will be observed in creep activation energy studies.

Generally, creep is controlled by diffusion processes at high temperatures, that is, at absolute temperatures greater than one-half the melting point of the metal. Zircaloy-2 has been found to behave in an anomalous fashion, in that the alpha to beta phase transformation temperature (865 C) rather than the melting temperature plays a role in determining the range in which diffusion processes occur rapidly; 300 C is very close to half the absolute temperature of the phase transformation, consequently, measurements of activation energies can be made in the range 275 C to 325 C. The in-reactor activation energy in this temperature range (62,000 cal/mole) is seen to include the energies for both vacancy formation and vacancy motion. This observation indicates that a major revision of the theoretical explanation of the effects of radiation on creep rates must be considered.

Capsule development is currently concerned with improving the heater life in the creep capsules. Heater failures, short of the expected lifetime, have been encountered on the last two capsules. In one capsule, the 250 C creep test, the test was terminated at 1407 hours due to a heater failure; in another, a heater failure occurred shortly after a test began. These capsules are not entire losses as activation energy measurements can be made when only one heater is gone. Heater failures were considered to be either from a deterioration with time and temperature, or from mechanical shock as a result of refluxing in the internal cooling tubes, or a combination of both. Two laboratory mockups of the heaters were constructed, both mockups approximating operational conditions with heaters and cooling coils operating in a pressurized helium atmosphere. Temperature cycling at 30 percent overloading failed to produce heater failures in a reasonable length of time. Consequently, the

voltage or aging problem was not considered to be the source of trouble. Another test was then begun with a constant power to the heater assembly, and water in the cooler tubes was allowed to reflux. The refluxing of the water in the tubes produced a mechanical shock that significantly reduced the heater lifetime. This thermal refluxing of the water in the coolers is a condition that is encountered in the in-reactor capsules when no water is being circulated through the cooling coils. In the reactor, water pressure in the cooling channel forces water back through the cooling coils in the capsule until it is flashed to steam at the heater. The steam condenses and the cycle repeats, giving a mechanical shock each cycle. To prevent the thermal refluxing, the exhaust line from the coolers was returned to the face of the reactor where a valve isolates the lines from the water pressure surrounding the capsule. With the line returned to the face of the reactor, the tubes can be drained of all water when cooling is not necessary, completely eliminating the possibility of refluxing.

Optimization of the saturable-reactor magnetic amplifier systems now in use to control the voltage to the heaters in the capsules has been completed. It was found that the open loop gain transfer function of the system is nonlinear. There are three basic modes of reactor operation, each of which affects the transfer function of the capsule: first, the reactor down and the water pressure down provides medium open loop gain; second, the reactor down and the water pressure up gives high open loop gain (close to instability); and, third, the reactor up and water pressure up reflects a low open loop gain (easy to control). Step response tests of control between the second and third modes of reactor operation (reactor down, water up and reactor up, water up) gave a change in temperature per milliamp control signal that was nearly doubled between the two reactor modes. At reactor up one milliamp control signal resulted in a 72 C temperature change, and at reactor down one milliamp signal represented 140 C change. This indicates that in order to control at all reactor modes, one of the elements of the open loop transfer function must be made nonlinear to compensate for the nonlinearity of the capsule. This could be accomplished by nonlinearization of the static transfer function of the magnetic amplifier saturable-reactor in such a way as to increase the gain at low power demand and decrease the gain at high power demand. A compromise, as is now the condition using the magnetic amplifier, is to set the control system to an optimum under the worst mode (reactor down, water pressure up) and thus control with a slower response time under all other modes. As such, the resulting temperature control of plus or minus one degree is obtainable under

all modes; however, a sudden change in reactor conditions reflects a temperature depression of several degrees (normally around five) and a slow recovery to the precise control point. The temperature depression can be eliminated only by manually adjusting the open loop gain at the time the transfer function changes; it cannot be corrected automatically using magnetic amplifier saturable-reactor systems. Although the present system is tolerable, experiments are being conducted with prototype assemblies of differential amplifiers and integrating networks to replace the magnetic amplifiers and saturable amplifiers to provide automatic nonlinearization of the control functions.

Irradiation Effects in Structural Materials

The purpose of this program is to investigate the combined effects of radiation and reactor environment on the mechanical properties of structural materials. Special attention will be given to the determination of mechanical property changes produced in metals by irradiation at elevated temperatures.

During the month 25 tensile specimens irradiated in the G-7 ETR hot water loop were tested at 300 C. One of these specimens was Zircaloy-2 and the remainder were types 304 and 348 stainless steel with varying amounts of cold work. An additional 26 Zircaloy-2 control tensile specimens with varying amounts of cold work were tested at room temperature. The raw data from these tests were programmed for electronic data processing.

Preliminary results of the tensile properties of a zirconium - 2 Sn - 2 Nb alloy, irradiated in the ETR at ambient coolant temperature, have been obtained. The alloy received an exposure of 1.1×10^{20} nvt (> 1 Mev). Prior to irradiation this alloy was heat treated to improve its properties. The heat treatment consisted of heating to 850 C for one hour, furnace cooling to various test temperatures, holding at these temperatures for one hour, then quenching in silicon oil. The entire heat treatment was conducted in a vacuum system maintained at five microns pressure.

The unirradiated room temperature 0.2 percent yield strength of this alloy quenched from 780, 740 and 660 C is 83,200, 81,500 and 74,500 psi, respectively. The average irradiated values are 115,200, 108,400 and 108,500 psi. The unirradiated yield strength values of Zircaloy-2 in the annealed, 20 percent, and 40 percent cold worked states are 47,300, 80,100 and 86,100 psi compared with 72,000, 96,500 and 101,000 psi for an exposure of 1.1×10^{20} nvt (> 1 Mev). The unirradiated ultimate strength for the zirconium -

2 Sn - 2 Nb alloy quenched from 780, 740 and 660 C is 108,000, 105,000 and 86,000 psi; average values of irradiated specimens are 129,000, 120,100 and 117,600 psi, respectively. Unirradiated Zircaloy-2 in the annealed, 20 percent and 40 percent cold worked condition has an ultimate strength of 66,400, 89,000 and 96,300 psi compared with 82,500, 99,000 and 108,000 psi for an exposure of approximately 10^{20} nvt. Total elongation is reduced from 15 to 3.8 percent in the zirconium - 2 Sn - 2 Nb alloy treated at 780 C and from 28 to 6.2 percent when treated at 660 C. Uniform elongation is similarly reduced from 7 to 2.8 percent for the 780 C quench and from 11 to 3.6 percent for the 660 C quench. These values are similar to reductions noted in total and uniform elongation for Zircaloy-2 in various states of cold work.

The data from these tests show that the strength characteristics of the zirconium - 2 Sn - 2 Nb alloy are superior to those of Zircaloy-2 at the temperatures of irradiation and testing imposed. The uniform elongation of this alloy, which is the property most drastically affected by neutron radiation, is also superior to that of Zircaloy-2. However, properties such as corrosion resistance and high temperature strength must be considered in evaluating the merit of this alloy for nuclear application.

Damage Mechanisms

The objective of this program is to establish the nature of interactions between defects present prior to irradiation and defects produced by irradiation, and to investigate the possibility of neutralizing the effect of impurity atoms by chemical stabilization. High-purity iron containing interstitial impurities, such as carbon and nitrogen, and a chemical stabilizer such as titanium will be studied.

A preliminary investigation of impurity effects in irradiated iron is continuing. Ingot iron which was decarburized and subsequently nitrogenized is the subject of this study. Damage recovery in irradiated ingot iron is presently being studied by means of electrical resistivity measurements. Three specimens, with exposures of 5×10^{17} , 1×10^{18} and 2×10^{18} nvt (fast) have been subjected to isochronal annealing treatments in 25 C increments up to 300 C. Very little can be said about the recovery characteristics except that the resistivity decrease is greater with increasing exposure. This suggests that only one recovery stage will occur at the higher exposures and two or more at the lower exposures. These studies will be extended to include decarburized and nitrogenized specimens.

A total of 6.3 pounds of high purity iron, containing 100 ppm impurity elements or less, is presently on hand. Reduction of this material to a usable geometry is awaiting delivery of special drawing dies.

Specimens of Inconel have been successfully thinned and examined by transmission electron microscopy. A large number of dislocations were observed despite the 926 annealing treatment. Pile-up of dislocations at grain boundaries and stacking faults were also observed. Since the major constituent of this alloy is nickel, a metal having a medium stacking fault energy, the observations are as expected. Efforts to thin samples of Inconel X and R-27, both nickel base alloys, are in progress.

High purity iron foils, 0.003-inch thick, cold rolled from iron rod stock, have been annealed at 600 C for two hours. Both the cold worked and annealed foils were thinned for transmission microscopy. As indicated previously, the specimens distort the electron beam in the immersion lens and for satisfactory results must be small in area. Attempts at obtaining small areas which are sufficiently thin and free of mechanical work due to cutting and manipulation are continuing.

Neutron Monitoring for Irradiation Experiments

Neutron spectra at various radial positions in K and C Reactor lattice have been calculated to determine the degree of complexity necessary for structural materials damage studies exposure calculations. Spectra were calculated using a continuous slowing model, diffusion theory code (GNU-II), a diffusion theory code with a transport scattering matrix (HFN) and a transport theory code, S_x . Significant differences in spectra calculated by these codes occurred and because the S_x results correlated more exactly with observed foil activities, future spectral calculations will be made with this model.

6. GAS GRAPHITE STUDIES

Microwave Activation of Gases

He, N₂, O₂ and CO₂ subjected to a microwave field are ionized. The following table lists the species which have been identified in the glow from these gases.

IDENTIFICATION OF SPECIES IN A MICROWAVE GLOW DISCHARGE

<u>Ionized Gas</u>	<u>Species Identified</u>
Helium	He (neutral atom)
Oxygen	O ₂ , O ₂ ⁺ , O, O ⁺ , O ₃
Nitrogen	N ₂ , N ₂ ⁺ , N, N ⁺
Carbon Dioxide	C ₂ (?), O ₂ , O ₂ ⁺ , CO ₂ or CO ₂ ⁺ , CO, CO ⁺ , C ₃ O ₂

The rate of reaction of activated CO₂ with graphite appears to be proportional to the geometric surface area of the sample. This implies that the pore structure is unimportant with respect to this reaction.

EGCR Graphite Irradiation. The fourth capsule, H-3-4, in the series of EGCR graphite irradiations was removed from the General Electric Test Reactor on July 24, 1962. The capsule was successfully irradiated for five reactor cycles for a total of 105.5 effective days at full reactor power. The maximum exposure received by the samples which have been irradiated in all four capsules of the H-3 series is estimated to be 1.1×10^{22} nvt, $E > 0.18$ Mev. The capsule was successfully disassembled in the hot cell and found to be in excellent condition. A small amount of carbon and graphite deposit was observed on the inner wall of the aluminum shell, as has been typical of all off-site graphite irradiation capsules. All samples and flux monitors were returned to Hanford and are currently being measured. Eight of the nine thermocouples in the capsule operated satisfactorily during the entire irradiation period, while number 7 failed eleven days before the end of the irradiation. Three of the thermocouples were saved and are being calibrated against a new thermocouple.

Construction has started on the fifth capsule, H-3-5, of the series. This capsule will contain 15 samples from H-3-4, three samples from H-3-3, and six new samples. It will be installed in the GETR during the first week in September and will be irradiated for four reactor cycles. The design of the capsule assembly was modified slightly so that the central cooling rings at each sample location are fixed in position. This should eliminate problems in shifting of these rings as the assembly is slid into the outer shell.

7. GRAPHITE RADIATION DAMAGE STUDIES

Radiation Exposure Units

Suggested exposure units for graphite irradiation include a fast-neutron flux based on Ni activation assuming a fission spectrum. A more refined technique, used at Hanford, incorporates a correction

factor based on calculated fast neutron spectra to compute the neutron flux above 0.18 Mev. The adequacy of these units has been checked against results from a calculation using the S_X code for a K-type reactor lattice. A Kinchin and Pease theory, modified for Rutherford scattering, was used to calculate the number of displacements. The effect of spectrum changes was assessed by performing calculations at various radii from the edge of the process channel to the graphite lattice boundary.

The ratio of the number of displacements to the equivalent fission flux from Ni activation varied from 0.46 to 0.76 (approximately 70% change) in arbitrary units from the edge of the process channel to the graphite lattice boundary. The magnitude of the difference illustrates the inadequacy of an exposure unit based on the assumption of an unmodified fission spectrum. In comparison the unit, $nvt E > 0.18$ Mev, including correction for the calculated spectra, yielded values for the above ratio which varied from 0.189 to 0.221 (~17% change) from the edge of the process channel to the graphite lattice boundary. Thus the unit, $nvt E > 0.18$ Mev, incorporating spectrum corrections is less sensitive to spectrum changes and hence more suitable for relating test reactor data to graphite moderated reactors.

8. ALUMINUM CORROSION AND ALLOY DEVELOPMENT

Aluminum Corrosion In-Reactor

The first test in H-1 Loop was discharged August 9. The primary purpose of the test was to determine the effect of reactor radiation on corrosion and crud deposition. Coupons of X-8001 and A-288 aluminum, nickel-plated aluminum, Zircaloy-2, stainless steel, and carbon steel were exposed both in and out of flux to recirculating deionized water. Total exposure during reactor operation was 1427 hours, of which 867 hours was at 290 C, 560 hours at lower temperatures. The total exposure is equivalent, in terms of expected corrosion, to 1092 hours at 290 C. The pH ranged from 6.1 to 8.9, with an average of 7.9. The resistivity of the water ranged from 200,000 to 1,200,000 ohm cm. This is somewhat poorer water purity and higher pH than had been hoped for from the mixed-bed clean-up ion-exchanger.

The three in-flux coupon holders have been discharged at Radiometallurgy and the coupons photographed. On the basis of visual observation, the aluminum coupons appeared to be rather heavily corroded and had a fairly heavy dark brown crud deposit. No corrosion was noticeable on the nickel-plated aluminum, but the crud deposit seemed to be as heavy as on the unplated aluminum. The same brown crud deposit was noticed on the stainless steel and Zircaloy-2 coupons.

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A few of the stainless steel and Zircaloy-2 coupons had been made with thin disks of silver welded inside them 0.010-inch from one face. A high beta flux occurs at the surface of the coupons as a result of formation of Ag-108 and Ag-110 by neutron absorption and subsequent decay by beta emission to give Cd-108 and Cd-110. The expected beta flux is estimated at two to three times that expected on the surface of the NPR fuel elements. Similar coupons of aluminum could not be included in this charge because of fabrication problems. As well as could be determined from visual observation, the amount of crud deposited was the same over the silver disk as over the outer edges of the coupons where the beta flux was not present. This would seem to indicate that the beta flux through the surface is not significant in producing crud deposition, except as it contributes along with gamma to the total dosage of ionizing radiation. The beta dosage at the surface of these coupons was comparable in terms of energy absorbed to that from gamma; a two-fold increase in total ionizing radiation would not necessarily produce a visually evident change in crud thickness.

The coupons exposed out of flux at the far downstream end of the charge did not show the brown crud deposit characteristic of the in-flux coupons.

More firm conclusions will be possible later when quantitative crud and corrosion data are available from measurements of weight losses and film weights.

The H-1 Loop is now being conditioned for the second test, at pH 4.5 with phosphoric acid.

9. USAEC-AECL COOPERATIVE PROGRAM ON DEVELOPMENT OF HEAVY WATER MODERATED POWER REACTORS

Thermal Hydraulic Studies

Eighteen boiling burnout points were determined during the second phase operation of the electrically heated model of a 0.050-inch spaced 19-rod bundle fuel element. The following range of data were obtained.

Mass Flow Rate Lb/hr-ft ² , x 10 ⁶	Burnout Heat Flux Btu/hr-ft ² , x 10 ⁶	Exit Conditions at Burnout	
		Quality, %	Subcooling, °F
0.5	0.30 to 0.49	17.6	to 134
1.0	0.50 to 0.97	14.0	to 139
2.0	0.63 to 0.94	6.7	to 52
3.0	0.71 to 1.12	4.3	to 72
4.0	1.10 to 1.52	--	8 to 74
5.0	1.30 and 1.73	--	12 and 37

All data were obtained at 1200 psig with the test section in a horizontal position.

This test section differed from the first 0.050-inch spaced test section in that the wire wraps used for spacing and flow mixing were made from Inconel tubing filled with compacted MgO instead of ceramic beads strung on wire as used previously. The change was made because some of the ceramic beads crushed and allowed the rods to bow toward each other during experimentations with the first test section.

The boiling burnout heat flux obtained with this second test section agreed reasonably well with the data from the previous test section at the higher flow rates but were 20 to 30 percent higher at the lower flow rates. Included in the design of the new test section were four thermocouples placed to measure sub-channel water temperatures at the discharge end of the test section. A cursory inspection of the temperatures recorded from these thermocouples indicated that there was not a wide spread in sub-channel water temperatures. This means that mixing was reasonably good in this test section and that the data obtained can be extrapolated to longer fuel elements with confidence. During the course of experimentation the new test section was operated at a mass flow rate of 5,000,000 lb/hr-sq ft. At this flow rate a boiling burnout heat flux in excess of 1,700,000 Btu/hr-sq ft was obtained at a sub-cooling of 36.8 F.

Dome Seal Type Nozzle Closures

Development effort on the dome seal type nozzle closure has been limited to stress analysis of the dome. General equations have been developed which may be applied, within certain limitations, to dome seals of varying spherical radius, thickness, material, etc. No calculations for a specific dome design have been made as yet.

10. REACTOR AND NUCLEAR SAFETY STUDIESAdvanced Reactor Concepts Studies

Fast Supercritical Pressure Power Reactor. The FSPPR is a 300 MWe fast reactor based on the Hanford SPPR design, the chief changes in physical arrangement being elimination of the water moderator, together with attendant changes in control system, cooling of the outer fuel cores, shielding, and fuel handling. Initial physics calculations are based on a 60-inch diameter core. With a two-foot blanket, the reactor diameter would be about 9 feet versus 12 feet for the SPPR. Average heat flux in this size core would be about 750,000 Btu/hr-ft², equal to the maximum in the SPPR. Better power flattening and higher temperature tubing materials can be employed in this design. A number of thermal, hydraulic, and mechanical core design parameters (e.g., insulation thickness number of tubes per element) have been incorporated into a single design worksheet to provide a means of rapidly estimating the relative importance of the parameters and to provide input for physics analyses.

Core design calculations were initiated for the FSPPR. The same 16-group diffusion theory model is being used which was set up for previous studies on more compact cores. Nuclear data for hydrogen was extracted from the GAM-1 code and transferred to the HFN library tape. A dummy case was then generated which provided fuel mixtures of the correct isotopic composition for subsequent cases. A parametric study is now being carried out. Examination of the neutron fluxes from the first reactor case indicates the neutron spectrum has a peak at about 0.6 Mev, falling to about half maximum at 0.05 Mev. The contribution of the hydrogen to spectral degradation does not appear to be severe.

5 Mwe Spacecraft Reactor. Study of this reactor was limited to estimating pressure drops in core configurations for two- and three-pass coolant flow. Multipass coolant flow may be required to limit coolant temperature at the outlet of channels if power distribution in the core changes greatly with time. It appears likely that this will be the case for any scheme using the reflector to control the present reference fast reactor core and compensate for burnup.

The ORNL program on boiling metal cooling and space reactor concepts was discussed with personnel at that site. The ORNL work is essentially a re-orientation of work initiated in the latter part of the aircraft reactor program there, but is directed toward early realization of a workable reactor system. The reactor systems discussed

operated at relatively low pressures and heat fluxes. Consideration is being given to plutonium as a fuel in their reactor systems.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

The main objective of this program is to establish how irradiation affects the properties of b.c.c. molybdenum and how interstitial impurities such as carbon perturb the damage state.

One of the techniques to be used in studying damage in molybdenum is calorimetry. Energy released by test specimens at particular temperatures will be measured in a differential calorimeter which had been constructed. In order that energy releases associated with "cold work" damage in polycrystalline specimens can be recognized, experiments have been performed to introduce sufficient cold work in non-irradiated molybdenum for subsequent energy release measurements. Reduction of 0.5-inch diameter rod stock by swaging was performed at a variety of temperatures -- 600 C, 400 C, 300 C and 200 C. The higher temperatures yielded sound metal, but only the outer layer of the rods showed a worked microstructure. For lower temperature of swaging, the rods could be reduced in cross section only a small amount before cracking occurred. A cold worked microstructure and increased microhardness was achieved in 0.5-inch diameter rods swaged to 0.257-inch diameter. Additional reduction in area resulted in cracking. Upsetting of molybdenum rods, 0.5-inch diameter by four stages to 0.795 at a temperature of 550 C, followed by swaging, resulted in failure of the metal; microhardness of the upset metal had increased. From these experiments it is concluded that "cold work" as such is difficult to introduce in the annealed, fine grained molybdenum stock available for use. A combination of upsetting operations and swaging may provide worked rod stock of the proper diameter for use as unirradiated test specimens for energy release studies.

Four additional single crystal specimens were subjected to tensile tests, each test being interrupted at intervals for x-ray examination. Previous experiments indicated the need for additional data in the interval just prior to failure, so this portion of the deformation was interrupted at more frequent intervals. The low carbon specimens fail only after being drawn to a chisel edge and at loads approaching zero, while the higher carbon samples fail at higher loads and leave a fracture surface having appreciable area.

Tensile axis movements are plotted on a stereographic projection to determine the deformation modes. Early stages are not well defined since the movements are small and erratic. Evidently deformation is quite complex in this region. Later deformation leading to failure is more simple. Detailed analyses of the data are being performed but are not complete.

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Field ion microscope emitters have been prepared by Linfield Research Institute personnel under contract DDR-146. The first emitter, prepared from a 1/8-inch diameter single crystal containing 200 ppm C became contaminated with fines during operation in the microscope. A second emitter prepared from a 1/16-inch diameter rod containing 20 ppm C produced a diffuse unresolved pattern. Experiments on specimens submitted to Linfield are continuing.

An electron beam zone refining unit has been put into operation. A single crystal molybdenum rod, 1/8-inch diameter by 13 inches length has been prepared by the floating zone technique. Experiments are currently being planned to grow crystals with particular orientations by a seeding process. Single crystal tensile specimens currently under irradiation cover a variety of axial orientations but do not include any examples of $[111]$ rod axis orientations. If such crystals can be grown with a minimum of effort, they will be submitted for irradiation.

Foil specimens of Johnson-Matthey molybdenum irradiated to 1×10^{20} nvt in the as-rolled state and in the stress relieved state have been annealed at 400 C, 500 C, and 600 C. Evidence of small defects were observed by transmission electron microscopy after the 400 C anneal. These defects increased in number and size after the higher temperature anneals. After the 600 C anneal there are approximately 3×10^{16} defects/cm³ and they have a size range of 25 to 150 Å. The origin and nature of these defects is not known at the present time. Examination of similar foils irradiated to higher neutron doses and foils containing carbon as an impurity should yield additional information on whether the observed damage is due to impurity atoms, trapping of defects, or if the defects produced by irradiation migrate and cluster.

E. CUSTOMER WORK

1. RADIOMETALLURGY EXAMINATIONS

Metallographic examinations have been started on a series of stress corrosion coupons from Purex storage tanks with no significant defects detected.

Examination of a ruptured production fuel element showed the failure was the result of mechanical damage. Visual examination of four overbore elements revealed "worm tracks" in the aluminum surface of two of the elements.

2. EQUIPMENT PROJECTS

A special viewing window for color photography of radioactive materials has been designed and fabricated using a solution of optical grade zinc bromide as shielding.

A marking device for zirconium process tubing has been designed and will be operable in the first part of September.

The Sunbeam Equipment Corporation will furnish design drawings by mid-September on an induction furnace for B Cell. Sunbeam estimates that construction of the furnace will start approximately six weeks after the design drawings are completed.

Pulse Annealing Furnace

A one-half-inch long dummy sample showed that the maximum temperature gradient was about 1 C over a temperature range of 190 C to 765 C and under static temperature conditions. Additional temperature measurements over the same range indicated the actual sample temperature was about 15 C higher than that measured by thermocouples directly under the sample holder. A correction will need to be made on irradiated samples where thermocouples are not attached directly to the sample in order to obtain an accurate temperature measurement.

Project CGH-858 (High Level Utility Cell)

Modification work on the lathe will be completed by the end of August and then the lathe will be test run. A field engineer, Mr. Henry Nielsen, from AMF conducted classes on proper installation, operation, and repair on the extended reach manipulators.

Project CGH-857 (Physical & Mechanical Properties Testing Cell)

All of the cell castings except the south panel are due for shipment about September 1, 1962. J. A. Jones has completed all floor penetrations and is installing piping and conduit preliminary to the arrival of cell castings. A new Instron tensile test unit is operational in "I" cell and extensometer accessories have been ordered.

3. METALLOGRAPHY LABORATORIES

Vendor supplied Zircaloy-2 fuel element supports delivered to FPD Coextruded Product Engineering exhibited various degrees of cracking at the bends. Samples submitted for metallographic examination

indicated that fully recrystallized Zircaloy-2 with a grain size of about 20 microns had been used to fabricate the supports. For an application of this type the material should have a grain size approaching or less than 10 microns according to work carried out by the Structural Materials Development Operation.

Samples from thorium - $2\frac{1}{2}\%$ uranium alloy extrusions are currently being polished for examination. The pieces have been successfully polished using a combination of mechanical and electrochemical procedures, but etching for structure has presented a problem. Most of the current etchants for thorium leave something to be desired with perhaps the possible exception of vacuum cathodic etching. Because cathodic etching is much more time consuming, further experimentation with various chemical and electrochemical reagents will continue.

Additional closure welds of vendor-supplied Inconel temperature detectors for the NPR were examined. Previous welds were deemed unsatisfactory due to the lack of penetration of the weld. The penetration on the present welds was four-fold greater and appeared satisfactory for cleanliness and lack of porosity.

4. N-REACTOR CHARGING MACHINE

Modification of the new limit switch assemblies which control the vertical movement of the machine while loading or unloading magazines was started. Fabrication of the rear pressure roller assembly and the magazine piston removal equipment was started.

The final report on Design Test Number 1 has been completed. This design test covers total machine weight, major subassembly weights, and estimated center of gravity of the assembled machine.

Rough drafts of reports have been completed for Design Test Number 4 for testing of the machine cross travel system reliability, and Design Test Number 13 for testing of the hydraulic system and components. The latter test includes pressure drop and flow measurements for portions of the system, pressure and flow settings for system components, and comments on various aspects of system installation, reliability and maintainability.

All testing has been completed as required by Design Test Number 7 for the mechanical portion of the plug conveyor subassemblies.

Portions of the testing on Design Tests 11 and 19, which cover the hydraulic connector subassemblies and the filtered water systems, respectively, have been completed.

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5. CONSULTATION WITH SAVANNAH RIVER LABORATORY ON PRTR STARTUP PROBLEMS

Discussions were held at Savannah River on PRTR equipment and operating startup problems of interest to HWCTR personnel. The HWCTR began power operation on August 11 and had reached 15 Mw on driver elements only at the time of the visit. The helium evolution and bubble collapse problem has been resolved to SRL's satisfaction by installing a baffle plate in the top of their reactor vessel to keep cool D₂O in contact with the helium and thereby limit helium pickup to less than 80 percent saturation (at reactor inlet conditions). Operation is currently at 60-65 percent saturation as measured by D₂O and helium flow from the degasser in their cleanup stream. Their interest lay chiefly in PRTR instrument, pump, compressor, and rupture monitor equipment experience, and in helium and D₂O losses. Current rate of helium consumption at HWCTR would amount to 150,000 scfm/mo. No figures were available for D₂O losses. Since HWCTR has no provisions for decontamination and they anticipate metallic fuel failures, there is intense interest in how the present PRTR situation is handled.

6. SPECIAL FABRICATIONS

Fission Product Transient Samples for Phillips

Sixteen fission product transient samples have been completed and shipped. Fabrication of the remaining samples is continuing. Satisfactory analytical results have been obtained for the irradiation samples containing U-235 aluminum alloy cores. Coextrusion of these samples is in progress.

Classification of PuO₂ for Biological Studies

Approximately 3.5 g of high exposure (30 percent Pu-240) PuO₂ was classified into five size ranges for Biology Operation. The size ranges were as follows:

1. greater than 5 microns
2. 1-5 microns
3. 0.5-1 micron
4. 0.1-0.5 micron
5. less than 0.1 micron.

The PuO₂ was calcined in air for two hours at 900 C. After calcining it was ground briefly with a new mortar and pestle. The classification was effected by settling in water to which a deflocculent had been added.

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Manager, Reactor and Fuels Research
and Development

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PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATIONMONTHLY REPORTAUGUST 1962FISSIONABLE MATERIALS - 02 PROGRAMREACTORN-Reactor Exponential Experiments

An error in the reported buckling of dry enriched NPR fuel with no flooding as reported in June has been noted. The correct value is $+28 \mu\text{B}$. It should be noted that the simulated flooding in the NPR steam vents was produced by laying strips of masonite flat in each channel: the exponential pile, however, is rotated by ninety degrees compared to the actual reactor. Thus the masonite strips would be on edge in the actual reactor.

Optimization of Retubed Lattices

The holes in the exponential mockup (as described in June) of the "C" reactor lattice have been plugged and new vertical and horizontal flux traverses have been performed. Preliminary results show a difference of 24 micro-bucks between the material buckling measured with and without the holes plugged for wet CIIN fuel elements. The measured extrapolation distances were .63, 1.26, and 1.65 inches in the side-to-side, front-to-rear, and vertical directions, respectively.

The measurements were performed with no control rods, with one "C" reactor control rod in the center of the pile, and with six "C" reactor control rods in approximately the "C" reactor control rod lattice spacing. The analysis assumed that all effective pile dimensions were unchanged by control rod insertion. A summary of the experiments is shown in the following table for the wet CIIN fuel, without flooding.

<u>Control Rods</u>	<u>$B^2(10^{-6} \text{cm}^{-2})$</u>	<u>$\Delta B^2(10^{-6} \text{cm}^{-2})$</u>	<u>Relaxation Length (cm)</u>
None	+ 58	0	63.96
1	- 42	-100*	53.88
6	-111	-169*	49.15

The control rod measurements have not been corrected for local control strength.

The error in buckling for all three experiments is approximately ± 6 micro-bucks.

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Measurement of the Angular Distribution of Thermal Neutrons at the Surface of Cadmium Rods

A Summary entitled "Measurement of the Angular Distribution of Thermal Neutrons at the Surface of Cadmium Rods" has been accepted by the ANS for presentation at the Washington meeting in November, 1962. The angular distribution has now been derived from a simple "optical path" concept to compare with the previous results from experiment and Program S-X calculations. This concept determines the flux at a given angle, θ , from a line integral along θ of the radial flux times the probability that a neutron traveling toward the bar at angle θ will escape collision ($1 - e^{-\Sigma t}$). Thus the angular flux is derived in a very simple manner from the radial flux. The results of this simple model agreed within a few percent with the results of the experiments and the S-X calculations.

The radial and angular fluxes have been calculated for 5.3" bars of either copper or cadmium. The results are sufficiently different to indicate that experiments with a copper bar (or some other weak absorber) would be both feasible and interesting. Design of suitable detectors for such a measurement is now under study.

All calculations have been made with a single thermal group of neutrons which does not properly reflect the spectral hardening in the copper. The need for a better treatment of hardening is indicated by the fact that the calculated flux in the center of the copper bar is 13% below the experimental result, although the drop in the flux near the surface of the bar is well reproduced. Cross sections are being generated for a multigroup calculation (10 non-overlapping thermal groups).

Spatial Resonance Self-Shielding

Assistance to Programming Operation on heterogeneous cell calculations continued. Program FINDT, as described in XDC-60-8-69, was used to prepare a 1983 energy level tape containing cross sections of U-235, U-238, Pu-239, Pu-240, and a 1/v absorber. The modified Doppler broadening code was checked out. Parametric sets of self-shielding factors vs. absorption cross section for a UO₂ rod with three configurations of PuO₂ (as an outer annulus, as a central rod, and homogenized) were generated in an S₄ transport approximation using program S-X.

Code Development

SIGMA-3H

Program SIGMA-3C, which writes a CALX data tape, has been modified to

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write an HFN data tape. This new program, called SIGMA-3H, picks the necessary information from the TAM, (combined TEMPEST AND GAM output) library tape, thus significantly reducing the chore of preparing input for HFN.

APDAC

Two recently detected bugs in APDAC were located and corrected. The first was due to incorrect derivation of the error analysis. The flaw did not affect the calculation of relative activities, but caused APDAC to generally underestimate errors in these activities. The second was a coding flaw, which caused APDAC to lose occasional pieces of data.

ICEDT

ICEDT, the complete exponential data reduction code, is 90 percent debugged. Arrangements have been made with Data Processing Control for production processing of the code, which will replace the three present codes VTQCL, CQFIT2, and BVTQCO.

Instrumentation

Tests were conducted at GE-APED on the prototype NPR Fuel Rupture Monitor gamma energy spectrometer and differential alarm module. It was determined that all major problems have been satisfactorily resolved and only a minor output connection problem remains. The general prototype performance met the requirements of HAPQ Specification HWS-8104. A design test report was started.

Technical assistance was provided Electrical and Instrumentation Design, CE&UO, regarding purchase specifications for a multichannel analyzer to be used in conjunction with the gamma energy monitor portion of the NPR Fuel Rupture Monitor.

An analysis was performed to devise a method for employing static laboratory data from the NPR startup instruments to determine whether or not the dynamic, period response, requirements for the system can be met. The devised technique, though not absolute, should provide a rapid answer as required.

Detailed design of fuel failure detection instrumentation for the NPR test loop at PRTR was sufficiently completed for equipment purchasing to be started. Technical assistance also was provided CE&UO in design of the mountings for the detectors and coolant sample chambers.

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Technical assistance was provided IPD and CE&UO regarding NPR nuclear instrumentation. A suggested test procedure was prepared for the NPR source range monitor. A number of suggestions were made for improvement of tests scheduled for the intermediate range monitor. Calculations were completed showing that the sensitivity of the ionization chambers could be doubled to improve the system performance.

Systems Studies

Work continued towards elucidating the relationships among neutron flux monitor signals and control rod positions in the production reactors. Information from the five flux chambers and four rod position sensors in KW-Reactor was recorded on magnetic tape on July 31. A rod movement and three flux chamber signals were recorded simultaneously during each of the 11 runs made. The information from the runs is being replotted in an attempt to define a usable relationship between rod movement and chamber reaction as a function of their relative positions. Measurement precision is degraded by the lack of up-to-date information on the relative chamber sensitivities and the uncertainties regarding temperature and flux distributions. Correlation of the results of a large number of tests should help to improve the estimates of the desired relationships.

Analog computer studies relating to reactor control were completed which indicate that control of large reactors may be possible with relatively simple techniques if the proper equivalent reactor model is assumed. Verification of the simplicity of the assumed equivalent model was accomplished using an 11-node simulation model of the reactor. It was found that control of reactor power in any or all regions could be exerted by realistic, straightforward techniques. Nyquist diagrams were made of the response of the equivalent structure to an input signal from the Boonshaft and Fuchs transfer function analyzer; Bode plots were made from the Nyquist diagrams. The Bode plots verified the expected simplicity of the assumed equivalent model.

NPR Project Section was provided technical assistance through review of test procedures for the following NPR instrument systems: Flow Monitor, Integrated Temperature and Data Logging System, Flow Data Logger, Temperature Monitor, and Central Data Logger. Comments were compiled and forwarded as appropriate.

Technical planning continued for a proposed large 300 Area General Purpose Analog Simulation Laboratory. This proposal supersedes an earlier one to build a simulation facility at 100-N and project management responsibility was accordingly transferred to HLO from IPD. Information relevant to use of the general purpose facility for NPR studies was obtained from IPD.

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CE&UO has been requested to assist in preparation of cost estimates for the 300 Area facility.

SEPARATIONS

Experiments with Plutonium Solutions

The program of critical mass experiments with plutonium-nitrate solutions was continued with measurements in the 14-inch diameter stainless steel sphere reflected with water. Plutonium concentrations were in the range of 44.5 to 70.4 g Pu/g. Experiments were made (though not completed) for determining the critical concentration of Pu in the full sphere at a nitric acid molarity of about six. Data were obtained for evaluating the effect of the stainless steel shell on the criticality of the water reflected sphere. In one series of experiments, the vessel was wrapped with 0.03-inch cadmium sheet and reflected with water. The data from these experiments are summarized in the following table. The current experiments with the water reflected sphere provide a needed tie point with the early Hanford P-11 experiments which were conducted with dilute Pu solutions.

The thin stainless steel shell slightly reduces the effectiveness of the water reflector. In terms of solution volume, the correction factor is ~ 8.4 ml/mil of stainless steel thickness; in the absence of the stainless steel, the critical volume would be about 0.37 liters smaller. In the case of the 14-inch vessel wrapped with 0.03-inch cadmium and reflected with water, a concentration of 69 g Pu/g would result in the vessel being critical when just full (23.22 liters) for an acid molarity of 3.9 (total nitrate 314 g/g); the critical mass is 1.60 Kg Pu under these conditions. The cadmium reduces the reflector savings of the water to something less than one inch of paraffin and to nearly the equivalent of one-half inch of paraffin.

A nominal reflector is defined in TID 7016, Rev. 1 (Nuclear Safety Guide) as one of water not more than one inch thick, or its nuclear equivalent. The results with the cadmium wrapped vessel are of particular interest in nuclear safety applications in the event of water flooding, etc.; i.e., the vessels may be sized larger (for a nominal reflector) when wrapped with cadmium. This is a way of assuring that one would have only a nominal reflector (a reflector the equivalent of one inch of water or less) in the event of water flooding (whenever water flooding is possible, the more restrictive critical dimensions for full water reflection have been used). Further data are being obtained for the effect of cadmium on the criticality of the water reflected vessel. Experiments are currently under way with the cadmium covered sphere utilizing plutonium-nitrate solutions with an acid molarity of about 1.4.

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CRITICALITY STUDIES WITH PLUTONIUM SOLUTIONS
IN 14-INCH DIAMETER STAINLESS STEEL SPHERE

(Measured Sphere Volume: 23.22 liters; Wall Thickness: 0.044-inch)

Experiment Number	Date	Reflector	Pu Conc. (g/l)	Acid Molarity	Sp.Gr.	H ₂ O (g/l)	Total NO ₃ (g/l)	H/Pu Atomic Ratio	Critical Volume (liters)	Critical Mass* (Kg Pu)
1142108	7-27-62	Water	57.0	6.00	1.276	777	431	387.0	21.2 +.05 -.06	1.21
1142109	7-30-62	Water	53.0	5.95	1.277	790	424	422.5	21.5 +.04 -.04	1.14
1142110	7-31-62	Water	49.2	5.96	1.268	794	421	457.4	22.6 +.05 -.06	1.11
1142111	8- 1-62	Water + 0.036" SS	49.2	5.96	1.268	794	421	457.4	22.9 +.02 -.02	1.13
1142112	8- 2-62	Water + 0.072" SS	49.5	6.01	1.268	786	424	450.5	23.2 +.06 -.08	1.15
1142113	8- 9-62	Water	44.5	5.49	1.261	825	386	521.6	23.2 +.06 -.09	1.03
1142114	8-20-62	Water + 0.03" Cd Shell	70.4	3.32	1.242	888	279	346.1	22.8 +.06 -.08	1.61
1142115	8-23-62	Water + 0.03" Cd Shell	70.1	3.47	1.244	883	290	346.2	22.9 +.06 -.08	1.61
1142116	8-27-62	Water + 0.03" Cd Shell	69.4	3.74	1.240	858	304	341.1	23.1 +.05 -.06	1.60

* Pu²⁴⁰ Content 4.6 Percent

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Buckling of Partially Filled Spheres

Because Critical Mass experiments most usually yield data on the critical parameters for a sphere not completely filled with fuel, it would be desirable to know the buckling of a partially filled sphere. Fairly reasonable buckling values have been obtained for partially filled bare spheres. The problem of partially filled reflected spheres is now being treated by attempting to calculate the ratio of reflector savings above and below the fuel surface. Three parameters are needed for this description. The first, the probability that neutrons on the inner surface of the reflector reach the fuel before restriking the reflector, was found analytically. The second, a reflection coefficient for neutrons entering the reflector, was found numerically for water as a function of the concentration of plutonium in the fuel. The third, the ratio of neutrons leaking out the top and curved surfaces, was calculated analytically for the hemisphere. An attempt to calculate this ratio for the general case using partial differences is under way. Knowledge of these three parameters enables one to calculate a buckling for the partially filled reflected sphere, from which a conversion to a full sphere with reflector may be made.

Comparison of the 14-inch Critical Sphere Data with Results of Early Hanford P-11 Experiments

Under the Hanford P-11 program, critical mass experiments were conducted with plutonium-nitrate solutions in a water reflected 14-inch sphere with Pu concentrations in the range of 26.33 to 41.12 g Pu/g. The most complete data obtained within the above range were for Pu containing 3.12% and 4.05% Pu²⁴⁰.

The present experimental program is being conducted to obtain data for higher concentrations of plutonium-water complexes than were measured under P-11. However, it is important that the present program verify some of the P-11 results to establish the consistency between the two programs. Experiments are now being conducted with a 14-inch water reflected sphere with plutonium concentrations within the range investigated by P-11. Before a comparison of the data can be made, the results of the P-11 experiments must be corrected for the differences in Pu²⁴⁰ content, i.e., from 4.05% to 4.6%, which is the Pu²⁴⁰ content of Pu in the current experiments. Corrections must also be made for slight differences in the solution volumes (the "14-inch" spheres were of slightly different volumes) and differences in the stainless steel shell thicknesses.

To make these corrections, a series of multi-group diffusion calculations were carried out with the HFN code. The multi-group constants used in the

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calculations were obtained from the GAM-I slowing down code for the fast group parameters and the thermal group parameters were obtained from the Tempest Code utilizing a Wigner-Wilkins spectrum.

The recent experimental results with the 14-inch water reflected sphere are in excellent agreement with the corrected P-11 data. The largest difference was less than 1% in the critical plutonium concentration at a nitrate concentration of 389 g/l, well within the experimental uncertainties of the critical mass measurements. (The uncertainty in the chemical analyses for the Pu concentrations is about 1%.)

An additional calculation of interest is the critical radius computed for the three critical concentrations by the HFN code with GAM-I and Tempest multi-group parameters. These results are given below.

<u>Pu(g/l)</u>	<u>NO₃(g/l)</u>	<u>14" Sphere Radius (cm)</u>	<u>Calculated Critical Radius (cm)</u>	<u>$\frac{\Delta \text{Vol}}{\text{Vol}}$ (%)</u>
33.0	162	17.698	17.453	4.15
38.5	293	17.698	17.467	3.92
44.1	387	17.698	17.437	4.42

Effect of Scatterers on Criticality

PuO₂-polystyrene compacts are being made for critical mass experiments; the PuO₂-plastic compacts will permit extending the criticality data to regions of higher concentration than obtainable with solutions. The plastic mixtures are plutonium oxide and polystyrene, (CH)_N, which is pressed into two-inch cubes. For such plastic compacts, the oxygen content is directly proportional to the plutonium density; not the hydrogen content as in aqueous solutions. Also, plastics such as polystyrene and polyethylene, (CH₂)_N, contain carbon which is usually not present in any significant quantities in an aqueous solution. The effect of carbon and oxygen on criticality is of particular interest.

Certainly the poison effect, neutron capture in oxygen and carbon, will be negligible in that the absorption cross sections are negligible; less than 0.2 mb and 4.0 mb, respectively, at 2200 m/sec. However, the scattering properties of oxygen and carbon should have a significant effect on criticality. Neutron scattering with hydrogen has a strong forward component which enhances the neutron leakage in comparison to other scatterers. The forward scattering component in oxygen and carbon is smaller,

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therefore, neutrons which scatter from either of these elements will have a larger probability of being returned toward their point of origin, thus reducing the neutron leakage.

An index of the oxygen effect on fast neutron leakage is obtained from a comparison of ages calculated by Goldstein, et al., (ORNL-2639) by the Monte Carlo Method for monoenergetic source neutrons (2 Mev) in water and in an idealized hydrogen medium having the same atomic density as water. The age in water is 24.6 cm², while that in pure hydrogen is 40.8 cm². It is therefore possible for systems with identical plutonium concentrations, and with hydrogen-to-plutonium ratios (H/Pu) which give nearly identical multiplication factors, to have quite different critical mass values.

To determine the effect of oxygen and carbon on the critical mass of a PuO₂-polystyrene mixture, multi-group diffusion calculations were made for an idealized Pu²³⁹-water solution and a hypothetical PuO₂-polystyrene mixture with identical plutonium concentrations (3.837 g/cc) and identical H/Pu ratios (5.0). This isolates the effect of scattering on criticality between the two systems from the density effect, i.e., the actual plutonium concentration for a PuO₂-polystyrene compact with an H/Pu ratio of 5 would be ~2.8 g/cc.

The GAM-I slowing down code was utilized to determine the eleven fast group parameters; the neutron age was calculated by the moments method. The thermal group parameters were computed with the Tempest Code utilizing a Wigner-Wilkins spectrum. The multi-group diffusion calculations were made with the HFN diffusion code in finite slab geometry with horizontal dimensions of 17.9 cm x 17.9 cm. The results are summarized below.

<u>System</u>	<u>H/Pu</u>	<u>Pu(g/cc)</u>	<u>k_∞</u>	<u>Fission Age to .4 ev(cm²)</u>	<u>Critical Slab Length (cm)</u>	<u>Critical Mass(Kg)</u>
Pu-water	5	3.837	1.97	25.6	29.17	35.9
PuO ₂ -(CH) _N	5	3.837	1.94	16.4	8.07	9.9

Assuming that the critical slab length is correct for the Pu-water system and applying simple age theory, which is not valid for these small systems, but which should be correct to within a few centimeters, the critical length for the hypothetical PuO₂-(CH)_N system is calculated to be 11.5 cm, which is within the expected agreement from the above result.

The effect of scatterers on criticality has been further explored by a series of multi-group diffusion calculations for which the oxygen content

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was hypothetically reduced in an idealized Pu^{239} -water solution (32 g/g plutonium) in steps of 25, 50, 75, and 100 percent. Similar calculations were carried out to investigate the scattering effect of carbon and nitrogen with hypothetical Pu^{239} - CH_2 and Pu^{239} - H_2N systems, respectively. The thermal group absorption of nitrogen was made zero in the calculations to isolate the nitrogen scattering effect on criticality. A summary of the results of this series of calculations for a fully reflected sphere is given below.

Percent of Scatterer Removed	Critical Radius of Fully Reflected Sphere (cm)		
	<u>Pu-H₂O</u>	<u>Pu-H₂C</u>	<u>Pu-H₂N</u>
0	13.93	13.77	15.28
25	14.56	14.47	15.67
50	15.31	15.26	16.05
75	16.20	16.19	16.65
100	17.30	17.30	17.30

As observed in the foregoing results, carbon is slightly more efficient than oxygen in reducing the neutron leakage, while the scattering effect of nitrogen is approximately one-half that of oxygen and carbon.

Most of the above effects of scattering on criticality are due to a reduction in the neutron leakage at very high neutron energies ($E > .025$ Mev), where the scattering cross sections of carbon, oxygen, and nitrogen become competitive with hydrogen. The scattering cross section of hydrogen is smaller at these energies than in the resonance region. To investigate this point, a multi-group diffusion calculation was made for an idealized Pu^{239} - H_2O solution (32 g/g plutonium) with oxygen transfers eliminated at energies in excess of 0.025 Mev. The critical radius in this calculation was 16.91 cm, indicating that the oxygen scattering effect below 0.025 Mev reduced the critical radius by only 0.39 whereas the effect above this energy contributed a reduction of 2.98 cm in the critical radius.

It is concluded from the above results that criticality of a hydrogenous system is a strong function of the amounts of scatterers present. Simple density corrections to systems of equal H/Pu ratio, but differing in scattering properties, are not valid.

Nuclear Safety in H₂O

One nuclear safety specification was issued: "M-1 Rules for Storing 1.8 w/o Pu-Al Alloy and Natural UO_2 Fuel Elements in the Plutonium Recycle Critical Facility".

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Comments were submitted to the Plutonium Metallurgy Operation concerning the safe handling of plutonium metallographic samples.

Nuclear Safety in FPD

Nuclear safety advice was provided concerning the processing of 1.6 w/o U^{235} enriched uranium fuel elements, the autoclaving of C and J fuel elements, the handling of mixed uranium enrichments, and the handling of 2.5 w/o U^{235} enriched thorium alloy billets. A temporary FPD nuclear safety specification was issued for processing the 1.6 w/o enriched uranium fuel elements.

Mass Spectrometry

Studies have continued on the poor operating characteristics of the heavy-element mass spectrometer for this program. Optical and physical measurements were carried out on the alignment of the spectrometer system while partially disassembled. An error in the angle between the ion-source axis and the median plane of the magnet gap was discovered and corrected. Operation of the spectrometer after correction shows that the effect of this angular error on spectrometer resolution has been corrected. Other aspects of the spectrometer alignment are still being studied.

Instrumentation and Systems Studies

The criticality alarms at the Critical Mass Laboratory are being altered to agree with the plant standard. Equipment has been ordered and installation should be complete within a month. Information as to which alarm has been actuated will be printed out on a digital printer. When the alarm point is reached, an "Electronic Sentry" will automatically telephone a preset number and announce this condition.

A long time-constant filter in the period section of the log n-period meter at the Critical Mass Laboratory has greatly reduced the number of false scrams caused by this instrument. It was discovered that signal fluctuations at the higher power levels were causing this condition and an appropriate filter was installed.

An aural monitor has been developed and will be installed at the CML and tested in the near future. The present aural monitor, connected to a fission counter, is difficult to use above about 20 counts per second since the output then sounds like a constant level noise. The new model will use a division circuit and a range switch to divide by 10, 100, and 1000.

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Work has been started on a prototype, low range period meter for the CML. The instrument will be fairly slow but will indicate periods longer than 100 seconds. Maximum readable periods on the existing instruments are about 100 seconds.

Operating tests of the control rod drive mechanism for use at the CML were satisfactorily completed. The tests included 1000 simulated rod drops. Repositioning accuracy was maintained to ± 0.015 inches. The controlled fall time was reduced by slight changes so it is now only 1.5 times longer than the free-fall time of 0.24 seconds.

A four-node model of a pot calciner has been studied using both analog computers. The amount of nonlinear equipment required caused some difficulty in checking out the problem. Most of the information desired was obtained. This problem requires 25 multipliers, 16 function generators, and 21 differential relays. A large share of the nonlinear equipment had to be specially fabricated.

A keyboard circuit was developed to enter program data on the paper tape readout of the data logging system for the C-Column facility. The keyboard and circuits were fabricated and are now in use. This is the third such keyboard installation on plant and the first to include a program pin-board for selection of tape code characters.

NEUTRON CROSS SECTION PROGRAM

Quasi-Elastic Scattering of Neutrons from Water

The analysis of previously obtained data on the quasi-elastic scattering of neutrons from water shows that the apparent broadening of the peaks with increasing scattering angle was larger than expected from measurements made elsewhere at lower neutron energies. A series of measurements has been started to repeat some of the previous data with significantly improved energy resolution in order to see if a systematic bias is introduced by resolution effects. Measurements have been completed at two scattering angles.

Inelastic Scattering of Neutrons from Water

A study of the Hanford and Chalk River results on the inelastic scattering of neutrons from room temperature water indicated that the scattering kernel might be represented in a simple functional form when the results are parameterized in an appropriate manner. A first attempt to derive a simple expression for the scattering kernel resulted in a function which gave a good fit to nearly all of the available data but failed to satisfy

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the necessary normalization conditions. Work is in progress to improve the parameterization in order to improve the quality of the fit and to satisfy the normalization conditions.

Rotating-Crystal Spectrometer

Design work continued on a rotating-crystal time-of-flight spectrometer for inelastic neutron scattering measurements. A small $\text{Li}^6\text{-ZnS}$ scintillator was studied for use as a type of detector for the spectrometer. The results of these studies showed promise, and a 5-inch-diameter detector has been ordered for further studies. A multi-tube BF_3 detector system was assembled for the initial measurements. An aluminum single-crystal which was previously grown at Hanford was used to fabricate a 1-3/4 inch diameter spherical crystal to be tried out for the rotating crystal. An optimum spatial orientation of the crystal lattice was calculated and measurements are in progress to align the crystal by means of neutron diffraction prior to the final machining and mounting of the crystal.

Fast Neutron Cross Sections

A series of total cross-section measurements from 3 to 15 Mev by the pulsed-beam time-of-flight technique was terminated by failure of the positive-ion Van de Graaff. Only a measurement on Ta was completed.

Total cross-section data on sodium which were obtained in June were processed through the data reduction program, BIG NED. These results showed that the energy scale discrepancy previously observed between earlier Hanford data and results obtained elsewhere at low neutron energies has now been eliminated.

A study has been made of the feasibility of using total cross section samples which are only 0.5 inch diameter in order to save costs on expensive samples. The use of the smaller diameter samples is indicated to be feasible, but experimental verification will be necessary before ordering the samples.

Instrumentation

The vernier chronotron coupler was installed and debugged for the fast neutron time-of-flight program. Special circuits were added to connect to the vacuum tube 256 channel analyzer. The coupler provides logic to remove an adjustable number of pulses from the start of the vernier chronotron pulse train. This allows the starting gate transient to be shifted off-scale, which provides about fifty additional channels for data. Logic is also provided for two side channels.

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Preliminary design work has been done on a motor drive system for a two crystal neutron beam chopper. The two crystals, each driven by a motor at about 12,000 RPM must be phase locked to 0.1° .

The 1024-channel time-of-flight analyzer for slow neutron cross section measurements remained in satisfactory continuous test operation during the month.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Graphite Lattice Parameters for Low Exposure Pu-Al Fuel

The analysis of the low exposure, Pu-Al fueled lattices using Program S has been unsuccessful. Calculated results for the poisoned lattices compare to experiment as follows:

<u>Lattice Spacing (In.)</u>	<u>K_∞ (Calc.)</u>	<u>Cu Cadmium Ratio (Cell Boundary)</u>	
		<u>Expt.</u>	<u>Calc.</u>
10-1/2	0.920	15.2	14.1
8-3/8	0.828	8.24	7.24
6-1/2	0.801	3.87	3.53

The discrepancies in these results are due in large part to a failure to take adequate account of the spectral shape of the neutron flux in the thermal region. At present there is no satisfactory means available locally to generate group transfer cross sections below cadmium cut-off.

High Exposure Pu-Al Lattice Studies

Preparation and planning work has been started for the lattice experiments in the PCTR with the high exposure ($\sim 22\%$ Pu²⁴⁰) Pu-Al fuel. Plans call for measurements to be made in graphite lattices in a manner similar to the earlier work with the low exposure Pu-Al fuel elements.

Low Exposure PuO₂-UO₂ Lattice Studies

Specifications for the low exposure PuO₂-UO₂ fuel elements have been revised. The purpose of the revision was to standardize the total length and the active core length of new fuel elements fabricated for use in PCTR and PRCF experiments.

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Effective Resonance Integral of Pu²⁴⁰

The analysis of the experiment to measure the effective resonance integral of Pu²⁴⁰ was discussed with Lawrence Dresner at Oak Ridge. The application of Dresner's theoretical work to the analysis appears to be correct. A summary of this work has been accepted for presentation at the winter meeting of the American Nuclear Society, and a manuscript describing this experiment in more detail is being prepared for submission to a technical journal.

The Critical Facility

Process specifications which will govern the operations of the PRCF have been reviewed and comments have been forwarded to the authors.

Calculations to estimate the reactivity changes which are to be expected from perturbations in the environment of a fuel element in the PRCF have been made as a function of position in the reactor. The calculations were made for removal of D₂O, addition of Al, or addition of H₂O. This information will be used to revise the detailed procedure for the startup experiment which is to measure the "Void, H₂O, and D₂O Substitution Coefficients." Two of the three unfinished startup-test procedures are complete and are being distributed for review and acceptance. The final test is being prepared by others. It is planned that the entire twenty-four tests shall constitute a supplement to HW-71214, the general descriptions of the tests. The introductory remarks for this supplement are being prepared.

Twelve 1/4" BF₃ counters to be used at startup have been calibrated on each of three different sets of counting equipment (each set consisting of a preamp, amplifier, high voltage supply and scaler). The required plots of counts per minute vs. pulse height voltage have been made for the thirty-six calibrations. In addition to this, the above twelve 1/4" and six 1/2" BF₃ counters have been calibrated on the 256 Channel Analyzer. The data taken from the analyzer consists of differential and integral tapes from which plots of counts per minute vs. pulse height voltage can be made. This information provides a standard against which the BF₃ counters can be checked.

Neutron Spectrum Studies

A report has been written for the Physics Research Quarterly Report (HW-74190) which describes the effects of foil thickness on the activities of Lu^{176m} and Lu¹⁷⁷.

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Corrections which would be used for determining spectral indices from lutetium irradiations in 19-rod clusters of UO_2 and Pu-Al fuel elements are being calculated. The calculations have been completed for the UO_2 cluster for foils at the cluster surface and in the center of the cluster. Similar calculations are being made for foils in a center rod, intermediate rod, and outer rod of a Pu-Al cluster.

Equipment has been received for counting beta particles and neutrons with solid state detectors. The equipment will be used for measuring beta-ray distributions with the Double-Focusing Beta-Ray Spectrometer and for studying neutron distributions in reactors. Modifications to the beta-ray spectrometer have begun in order to position a solid state detector in place of the Geiger counter which was used previously.

Critical Mass Studies for 1.8 w/o Pu-Al Fuel

The approach to critical experiments with the two zone loadings have been completed. The lattice spacing used was 0.85 inches center-to-center. The result reported last month for the low concentration of Pu^{240} in the inner zone was changed from 486 rods to 485 rods for the critical mass after a least squares analysis had been run on the data.

The experiment with the high concentration of Pu^{240} in the inner zone indicates that 490 rods results in a critical loading in this case.

A computer program has been written for equating the buckling expression for an exponential experiment to that of a critical experiment. The analysis involves an iteration on the equality to determine the value for λ , the extrapolation distance plus reflector savings. The value for the critical buckling B_c^2 is also calculated. If the input to the program includes the errors on the critical number of rods and on the reciprocal of the slope of the vertical traverse from the exponential experiment, then the errors on λ and B_c^2 are calculated by the program and appear in the output.

PRTR Fuel Irradiation Experiment

The scintillation counters which were used to count the lutetium foils have been recalibrated. The calibration factor is a proportionality constant. These constants convert the ratio of the lutetium activities to a quantity which can be correlated to the spectral index. The calibration factor is 2% higher than had been determined previously. The effect of this recalibration is to increase the value of the spectral index to $332 \pm 10^\circ\text{K}$ (from $327 \pm 10^\circ\text{K}$ reported previously) for the average value along the Pu-Al fuel element. This analysis was made with the assumption

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that the shape of the function which joins the slowing-down distribution to the Maxwellian distribution is typical of that in the moderator. Thus, the value of the spectral index may be slightly different as a result of the reanalysis assuming a distribution of neutrons appropriate for the outer ring of fuel rods in the cluster.

ARMF-MTR Experiments with Plutonium Fuel

An outline of an experiment to measure the effect of a Pu-Al sample on the spectrum in the ARMF has been written. The data from the reactivity measurements on the ARMF fuel standards in the PCTR have been analyzed to yield the boron and plutonium contents of each sample and the work is reported in HW-74796. The experiment demonstrated the use of the PCTR as an instrument to measure the quantity of neutron absorbing and fissile material in a sample without destroying the sample. The plutonium content was determined from reactivity measurements of the same sample taken first in a graphite core and then inside a water jacket. The plutonium content was found to an accuracy of 9% and the boron to an accuracy of 3%.

Physics Statics Calculations for a Series of Fast Spectrum Oxide Reactors

The parametric survey of fast oxide reactors started during early 1962 has been completed in cooperation with the Reactor Engineering Development Operation.

Some interest seems to exist in the possibility of using fast reactors for the production of high grade Pu-239 or of target materials for Pu-238 and U-232 production. The purpose of the present study was to obtain sufficient physics statics data which could serve as the basis for preliminary economic evaluations of various fast reactor utilization proposals. A very wide range of power levels (100 MW - 10,000 MW) was considered. Most of the reactors investigated were fueled with U-235 and U-238 but some Pu U-238 and Pu Th-232 systems were also considered. The Pu Th-232 case is interesting, because in this type of reactor, "dirty" Pu from some thermal power reactor can be transformed to U-233 in the reactor core and to pure Pu-239 in the reactor breeding blanket. In a typical 1000 MW, ThO₂ core, fueled with highly exposed plutonium, the initial core breeding ratio was found to be 0.98 and the blanket breeding ratio was 0.38. An informal Hanford document, HW-74739, summarizing the results of this study, is in preparation.

Phoenix Fueling of Compact, Water Moderated Reactors

A fairly detailed series of investigations of the use of Phoenix fuel for compact, water moderated power reactors has been started. These investigations are an outgrowth of previous work done for a small, Phoenix-fueled, pressurized water reactor (HW-71279). In the present study, three

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reactor types have been identified, so far, as being potential candidates for Phoenix fueling:

- (1) A zirconium-water reactor, with a fuel cell geometry patterned after the PWR seed elements.
- (2) A stainless steel-water core patterned after the APPR.
- (3) An air cooled, water moderated, nichrome reactor based on the "630 a Maritime Nuclear Steam Generator" proposal (GEMP-108).

Reactor models, suitable for analysis, have been devised, and cross section data are being generated by means of the TEMPEST and GAM codes.

PRTR "Phoenix" Fuel Experiment

Further analysis of the "hard spectrum" Phoenix experiment in the central PRTR cell has been carried out. At the present time, a combined SWAP-MELEAGER analysis of the central cell burnout is in progress. More refined calculations using a TEMPEST-GAM-HFN routine have also been started.

PRTR Experiments

Preparations have been completed for the disassembly of fuel element 5051 (first of the low exposure Pu-Al elements in the test series).

Nelkin Scattering Kernel for Water

With the availability of the Hanford scattering data for water, supplemented by the ChalkRiver data, one can compare in detail the Nelkin scattering kernel with experiment. For this comparison, both theoretical and experimental results have been expressed in terms of the Egelstaff scattering law. The Egelstaff scattering law expresses differential cross sections in terms of a simple energy dependent factor, and a more complicated factor, the S factor, which depends on energy transfer and momentum transfer only. While there is reasonable agreement between theoretically and experimentally derived S factors for certain values of the energy transfer, there are certain values for which the S factors show serious disagreement. This disagreement may indicate that the theory is seriously inadequate. However, since the Nelkin kernel is evaluated by a machine program, there is also the possibility that the disagreement is due to errors generated by the machine program. Currently the machine program is being studied in detail.

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A second problem with the Nelkin kernel is the apparent failure of detailed balance in the regions of high energy transfers. Since there are few experimental data for high energy transfers at present, it is not possible to determine the seriousness of this failure. A possible reformulation of the water kernel that would avoid this problem is being studied.

Code Development

CALX

Debugging of CALX is proceeding satisfactorily, and the document rough draft has been started. Debugging to date has consisted of running one-group, infinite medium calculations. Cases involving either one or five fuel isotopes, with one fission product, have run successfully, both on single pass and recycle operation. Most of the reactivity initialization options have been proved out, with one option still being checked.

The multi-group reactivity and flux calculation subroutine (program ANNE) is being recompiled to incorporate improved methods of calculation.

RBU

Analysis of the theoretical expressions for $\overline{\mu_0}(E_0)$, average cosine of the scattering angle, and the average energy change, $\overline{\Delta E}(E_0)$, derived from the gas kernel, indicates that the two-mass approach, to account for chemical binding effects on neutron thermalization, shows sufficient promise to warrant further development. A machine program to evaluate $\overline{\mu_0}(E_0)$ and $\overline{\Delta E}(E_0)$ as functions of μ and Δ (the mass parameters) is 60 percent completed.

RBU Cross Section Updating

Eleven isotopes pertinent to PRTR reactor physics analysis have been updated on the RBU library tape. Those isotopes thus treated are: Uranium (235, 236, and 238); Plutonium (239, 240, 241, and 242); and D², He⁴, O¹⁶, Zr(natural).

Instrumentation and Systems Studies

Technical assistance was provided regarding adjustment and modifications of the PRTR Fuel Rupture Monitor. It was determined that extremely high activity in the gas sample chambers tended to drive the count-rate meters full scale on the highest range and that rate-meter discriminators had been set to the marginal operation point in an attempt to bring the rate-

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meter readings onto scale. At increasing rates, this adjustment actually caused the meters to read downscale. The discriminators were properly reset and the detectors were moved further from the sample in two chambers until the rate-meters read 20% of full scale on the highest range. As an alternate, a lead plug was fabricated and inserted into the third sample chamber in front of the detector. This plug, which had a 0.375 inch hole in it, also provided a rate reduction to 20% of full scale on the high range. An emitter follower preamplifier was designed, fabricated, and attached to the probe of the fourth chamber. The output of this probe, which is available for insertion and testing of any sample chamber, was cabled to the control room multichannel analyzer for gamma energy spectral analysis work.

Shielding calculations were made to determine the required thickness for the door between the airlock cell and the cask handling area of the Fuels Recycle Pilot Plant. Plans to process fuel elements of different geometries than previously considered required some changes in the design bases for radiation shielding.

All laboratory testing was successfully completed on the second generation, final model, scintillation, transistorized, effluent monitor for gamma emitters for use at PRTR in the containment trip circuit. The instrument is ready for installation by PRTR personnel and will replace the first prototype which was temporarily installed as a replacement for the original inadequate equipment. The new model has improved electronic trip circuits and final packaging.

Instructions were provided Structural Materials Operation for calibration of the recently assembled Mark II probe for measuring the process-to-shroud tube annulus in the PRTR. Nine spare test coils were fabricated and delivered also.

Development was started on instrumentation for measuring the vibration of PRTR fuel elements, both in the hot loop mockup facility in the 314 Building and ultimately in the PRTR. The feasibility of using a dual probe eddy current sensor was determined with a laboratory mockup. A basic sensitivity of two millivolts per 0.001 inch displacement between a fuel rod and the process tube was observed over the total possible range of process-to-shroud tube relative displacements. This signal sensitivity is sufficient for recording. The probe will have to operate at temperatures up to about 500°F and selection of suitable materials and calibration procedures poses a number of difficult design problems.

PRTR Test Number 35, a repeat of PRTR Test Number 12, on reactor noise analyses, was performed during the week of August 13-17. The test called

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for the simultaneous, tape recording of information from the servomanometer, moderator level dip tubes, galvanometer chamber, and two flux chambers. Information from the galvanometer chamber was not recorded because of difficulties with ground loops in the measuring circuit. The reactor power level and moderator level were held as steady as possible during the recording. However, usable test instrument sensitivities were limited by moderator level variations; thus reducing the signal-to-noise ratio of the data and the accuracy of the results. All test equipment has been removed from PRTR and the PRTR systems have been returned to normal. Analysis of the data is in progress.

Initial investigation and evaluation of an analog power-spectrum analyzer operating on Fourier analysis principles were completed. The findings of this study will form the basis of a report which presents the theoretical basis for and the practical aspects of this analyzer. A rough draft of the report is completed.

A PRP Critical Facility analog study to determine the nuclear accident potential of the reactor using various types of fuel elements in the core was completed. Since the moderator-coolant of the Critical Facility reactor is in direct contact with the core, previous studies were made using a greatly simplified heat transfer model. The most recent study used a much more elaborate model including steam and void formation in the moderator and the effect of moderator boiling at the surface of the fuel elements.

Work started on an analog simulation to study possible nuclear excursions in the PRTR with various fuel loadings. Maximum power levels and maximum fuel temperatures are being determined for excursions resulting from various postulated reactivity disturbances.

NEUTRON FLUX MONITORS

A series of revisions and corrections to the neutron regenerating detector computer program was established. The program was then used in a series of runs using U^{238} , U^{234} , and Pu^{240} as the constituents. Temperatures of 100, 400, and 800°C were used for the spectral parameters (r values) of 0.00, 0.04, and 0.08. These values were expected to bracket actual reactor operation conditions. For those fertile nuclides with cross sections strongly dependent on neutron temperature and spectrum, the optimal initial composition and the useful lifetime expectancy were determined to be grossly different in the various cases. It had been assumed in the calculations that the U^{234} cross section was constant; therefore, the optimal composition and useful lifetime of the detector were similar in all cases. It is concluded that it would be an advantage

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to use a fertile material with a constant cross section; however, more detailed U^{234} cross section information is needed to establish its usefulness as a fertile material in the regenerating detectors. The cross section of Th^{232} is less dependent on temperature and spectral hardness than are cross sections of U^{238} and Pu^{240} ; however, Th^{232} has not been considered because of the long incubation period between the neutron capture process and the appearance of the fissile nuclei. Although the fertile material cross section establishes the basic useful detector lifetime, the fissile nuclide cross sections also influence the lifetime so no simple relationship exists which can be used readily to estimate the useful life expectancy of a given set of nuclides.

Formal document, HW-73335, "Feasibility Study of In-Core Neutron Flux Monitoring with Regenerating Detectors", D. E. Hegberg was issued.

NONDESTRUCTIVE TESTING RESEARCH

Electromagnetic Testing

An investigation of the diffusion and propagation of electric fields and



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Work on the multifrequency eddy current test unit is proceeding. Through the use of breadboard circuitry, it was proved that the various frequency components can be nulled and separated from the composite signal with the proposed circuits. Accordingly, a tuned amplifier incorporating automatic gain control and a detector stage was designed and tested. Five of these tuned amplifiers have been constructed for the five frequencies to be used. Testing of these amplifiers is now being completed. These tuned amplifiers (and the oscillators) are made as plug-in units so that different frequencies can be used at a later date if desired. The four L-C type oscillators are being converted to crystal oscillators for greater stability. These oscillators were designed so they could be converted with a minimum of new wiring.

The new graphical nulling unit permits the nulling or near nulling of the eddy current test probe signal by means of the adjustment of a single control lever which moves in a plane representing the voltage plane of the test coil output. A special feature of the device is that a graphical plot of the test coil output voltage may be made simply and directly. This makes it possible to readily relate the test coil output signals to published and experimentally determined patterns. Tests of the device mounted on an eddy current tubing tester show that it will facilitate the adjustment of the tester and the interpretation of test results. Tests show that the resolution and linearity of the present model need to be increased for working with small irregularities; for example, 0.005 inch electro-machine notches in 0.25 inch O.D. Inconel tubing having 0.050 inch wall.

An invention disclosure, HW-74595, titled "Eddy Current Nondestructive Testing Device with Graphical Nulling Feature" was prepared and forwarded to the Patent Attorney.

Zirconium Hydride Detection

Results of X-ray analysis of hydrided Zircaloy-2 samples, using a rotating sample holder, agreed qualitatively with previous X-ray studies. Sonic damping appears to correlate with hydride content in small Zircaloy-2 coupons. A coupling jig for stress-attenuation studies has been designed. A literature search reveals that there are at least three main proposed mechanisms of hydrogen embrittlement in Zircaloy-2.

The X-ray analysis was made by Chemical Separations, HLO, at our request. A rotating sample holder was used in an attempt to reduce preferred orientation effects which have prevented quantitative analysis for surface hydride concentrations in these studies. The preferred orientation effects were not reduced enough to obtain quantitative results. However,

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good qualitative sensitivity to hydride concentrations down to 300 ppm was obtained. This agrees with previous work reported in the October, November, December 1961 quarterly report.

Sonic damping measurements were made by FPD on the same group of samples being used for the X-ray studies (coupons approximately .02 x .6 x 2 inches containing 10, 100, 300, 400, 700, 1000, and 5000 ppm hydrogen). Damping at a frequency of approximately two kc increased with increasing hydrogen concentration.

Ultrasonic methods are useful for examining small areas due to the "beaming" effect which occurs for a piston type transducer at high frequencies. Possible mechanisms for ultrasonic stress-attenuation effects, based on dislocation theory, were described in the April, May, June Quarterly Report. The sonic damping results, mentioned above, may indicate that hydride causes an increase in stress induced dislocation movement. (However, it could also indicate an effect due to hydrogen diffusion within, or at the boundaries of, hydride platelets.) According to the proposed mechanisms, stress induced dislocation movement would cause an increase in ultrasonic attenuation. An apparent effect of stress on ultrasonic attenuation has been observed, but has been questionable due to variations in coupling during stressing the samples. A jig to accurately maintain the sample to transducer spacing during stress application was designed and fabrication costs were estimated by Technical Shops. Other possible coupling and transducing methods are being considered also.

A literature search revealed that one proposed mechanism of hydrogen embrittlement in Zircaloy-2 is based on realignment of slip planes in zirconium hydride platelets at 830 ppm hydrogen content so they are not parallel to slip planes in the metal. Another mechanism, which would be effective at high strain rates, is based on the intersection of twins with hydride platelets, and subsequent formation of microcracks. A third mechanism is based on initiation of microcracks due to the high stress field around a hydride platelet.

Heat Transfer Testing

Five Savannah River and three Hanford aluminum clad uranium fuel elements were heat transfer tested, and results from the HAP0 fuel element tests were compared with autoradiographs. Tests have shown that the water cooled lens barrel improved stability of the heat transfer tester.

The Savannah River fuel elements were the hot-die sized type. The cladding of two had been anodized on the inside surface prior to sizing, and the others had been left in the normal condition. Apparent heat transfer

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defects approximately 1/4 inch in diameter were found in one anodized, and in one of the normal fuel elements. However, the signals were at the limit of sensitivity for the test.

Comparison of heat transfer test results with autoradiographs of the HAPC fuel elements showed that two of the elements, which give no heat transfer defect indications, had porosity (void less than 1/4 inch diameter) in the AlSi braze layer. Heat transfer defects which were detected in the remaining HAPC fuel element corresponded to voids approximately 1/4 inch in diameter.

Tests show that installation of the water cooled lens barrel on the radiometer closest to the plasma heat source has improved the stability of the radiometer. Thus, the increase in signal which previously occurred during each fuel element test, and interfered with operation of the dual radiometer system now under development, has been greatly reduced.

Other Tests

An invention disclosure, HWIR-1540, "A Hall Effect Magnetometer for the Nondestructive Testing of Steel" was prepared and forwarded to the Patent Attorney.

USAEC-AECL COOPERATIVE PROGRAM

Nondestructive Testing of Sheath Tubing

Studies to compare the ultrasonic response of drilled holes with notches were continued with the aim of arriving at suitable standards and calibration procedures for the fuel element sheath tube test. Both the longitudinal and transverse tests were investigated using several ultrasound entry angles. A 0.005 inch diameter hole drilled through a 0.030 inch thick wall, 0.750 inch outside diameter tube was found to have a response appearing to be a composite of the response from respective outside and inside surface notches of about one wall thickness in length and one-tenth wall thickness in depth. The signal amplitude for this size hole was within 10% of the notch signal amplitude under certain conditions; which indicates that a hole standard would be suitable for setting proper instrument gain. However, the gate setting must be accurately positioned in order that both outside and inside surface defects are equally detectable. This requirement appears to be best established through the use of notches. It may be practical to use notches as primary standards and drilled holes as secondary, or working standards.

In previous work on test evaluation, tentative agreement was obtained between the measured ultrasonic response to defect depth and that predicted analytically. The response is dependent upon the Lamb-wave modes used, and in some

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cases, it remains constant, or even decreases, as the notch is made deeper, rather than increasing uniformly. Since such conditions critically affect the use of Lamb-wave propagation for tubing tests, the exact response needs to be established. Additional sets of transverse and longitudinal notches are being fabricated for use in completing the studies with 0.035" wall thickness tubing and for extending the results to 0.017" wall thickness Zircaloy tubing. The new notches vary in depth from 1/10 to 1/2 the wall thickness in 1/10 wall thickness steps.

Evaluation of the tentative calibration and test procedures under production conditions was started. As an initial effort, a cooperative program was established with one of the tubing manufacturers (Harvey Aluminum) to ultrasonically test 200 tubes (0.505" O.D. x 0.030" wall, Zircaloy) according to our procedures. The tubing plant was visited and the tubes were tested as prescribed within the limits of the available equipment. When the tubes are received at Hanford, they will be tested again with ultrasonics, fluorescent penetrant tested, visually examined, and destructively analyzed.

Prior to performing the test in the manufacturer's plant, three standards were fabricated. Each standard contained outside and inside surface longitudinal notches and an outside transverse notch; all were electro-machined. The notches were made on wall thickness (0.030") long by 0.0015" deep. Replication of the notches indicated good reproducibility in machining, the greatest variation was 0.001". The ultrasonic responses for all notches on the three standards were obtained under production test conditions using the Hanford equipment. Ultrasonic response reproducibility was within 10% for all notches, including inside and outside surface notches. One of the standards was used by the manufacturer in running his tests.

A fundamental analytical study to formulate a physical interpretation of Lamb-wave propagation in plates for phase velocities greater than the Zircaloy longitudinal velocity was completed. The study treated Lamb-wave excitation as the simultaneous propagation of shear and longitudinal components, and predicted the sound amplitude ratios within the metal specimen. It was based on the premise that as Lamb-waves approach a plate edge where a metal-water boundary exists, the longitudinal and shear components should separate into a predictable pattern in the water. Schlieren images of plate end leakage during Lamb-wave propagation demonstrated that the analytical study was approximately valid. Accurate determination of sound amplitude ratios by experimental methods was difficult because of sound diffraction effects which were not included in the analytical work. However, the experimental work did provide verification of predicted amplitude differences which were fairly large.

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BIOLOGY AND MEDICINE - 06 PROGRAM

Atmospheric Physics

A series of nine successful dispersion experiments, designed to clarify certain features noted in the 1959 Green Glow data relating to emission duration, travel time to a given distance, and averaging time of meteorological parameters in relation to dispersion parameters during stable atmospheric conditions, were completed. All tests were conducted during the night-time hours, using a continuous source near ground level. In addition to the extensive vertical and horizontal sampling grid extending to two miles from the source, the sampler arc at eight miles was reactivated and used during five experiments. Release periods varied from one-half to three and one-half hours. Exposure data were collected serially at selected locations with the modified drum samplers. In contrast to earlier experience, no problem with obscuration of samples by natural atmospheric dust occurred during this series.

The second, in a series of experiments to measure directly the dry deposition of zinc sulfide tracer material on vegetation, was completed on August 28. Because of possible cross-contamination between experiments, all equipment was moved from the 200N site, used previously, to a new site near the old Hanford Townsite. The test area was uniformly covered with cheat grass averaging 35 centimeters in height. Zinc sulfide released from a ground source was sampled at a height of 1.5 meters on arcs at distances of 25, 50, and 100 meters. Samples of cheat grass and organic ground surface material were collected at regular intervals along arcs at the above distance. These samples will be ashed and assayed with the Tri-Carb Scintillation Spectrometer to yield deposition measurements.

Summaries of gross statistics of data from 60 Hanford diffusion experiments conducted during the period 1959-1962 and 76 experiments at Cape Canaveral, Florida, conducted during 1961-1962 were completed. All of these experiments employed the same experimental design and assaying technique, and have a common source height of about two meters. A power function relationship was fit to the decrease of normalized centerline exposure, E_p/Q_T , with distance of the form

$$E_p/Q_T = ax^b,$$

where x is the distance from the source. Values of the parameters found are tabled below.

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<u>Test Series</u>	<u>a</u>	<u>b</u>	<u>Number of Experiments</u>
1959 Hanford (Stable)	6.3	-1.8	18
30 Series (Stable)	4.2	-1.7	17
30 Series (Unstable)	14.9	-2.1	12
Cape Canaveral (Stable)	18.1	-1.9	19
Cape Canaveral (Unstable)	12.9	-2.0	55

Dosimetry

Measurement of the radioactivity in Alaskan Eskimos continued. The apparatus was taken to Anaktuvuk Pass, a small village in the interior of Alaska. No accommodations for the counter were available so it was necessary to build temporary ones in the open. The counter was supported on timbers placed in a hole dug down to permafrost. Protection from rain and dust was provided by a wood framework covered with plastic sheets; a floor was made of sheets of plywood. When the measurements at Anaktuvuk were completed, the counter was returned to Kotzebue. There, a small group of people from the Diomed Islands and a few more people from villages around Kotzebue were counted. The counter was then moved to the village of Point Hope, the last village it is planned to visit.

Some of the results of the Eskimo studies are now available. The Cs-137 body burdens for permanent residents of different Alaskan villages are given in the following table. These results may be changed slightly if data are added or eliminated or minor calibration changes are necessary.

Cs-137 Body Burdens in Alaskan Eskimo Villages

<u>Village</u>	<u>Number of Subjects</u>	<u>nc of Cs-137</u>		
		<u>Minimum</u>	<u>Maximum</u>	<u>Average</u>
Barrow	259	8	166	52
Kotzebue	132	17	518	138
Anaktuvuk	52	83	790	421

For comparison, the average body burden of CS-137 of subjects counted at the Hanford whole body counter during this period was 5 to 7 nc. The first measurements on Lapplanders gave as high as 361 nc. Numerous measurements made in the Fall of 1961 gave 320 and 190 nc average body burdens for male and female Swedish Lapps and 243 and 123 nc for Finnish Lapps, respectively.

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A rough explanation, that is quite probably the correct one, can be given for the different average burdens in these villages: All of these people get a good share of their food from stores. Most of the store food comes from the other states and is not expected to produce high or very different Cs-137 body burdens. At the inland village of Anaktuvuk Pass, about half the food eaten is caribou which they hunt. Caribou are known to contain considerable Cs-137. At Barrow, the people get more of their food from the store; the rest of their diet is caribou and sea food. Sea food contains very little Cs-137. At Kotzebue, the proportion of food obtained from stores is about the same as at Barrow, but the people also eat considerable reindeer meat obtained from domestic herds. The reindeer meat seems to contain even more Cs-137 than the caribou.

A study was begun of the use of pure CsI scintillations at liquid nitrogen temperatures. The purpose was to explore the advantages of low temperature operation in reducing photomultiplier noise and in producing large scintillation pulses from the CsI. Techniques for counting at low temperatures were worked out. Initial tests were made with granular layers of CsI. These performed satisfactorily except that no photopeak resolution was obtainable.

The new accelerating tube obtained for the Van de Graaff last month appeared to be unsatisfactory. It was returned and another one obtained. It, too, appeared to be unsatisfactory in the same way. Exhaustive tests were made of the Van de Graaff without finding anything else that might be at fault. Finally, it was found that removing the recently installed ion-getter pump eliminated the trouble, i.e., the accelerating tubes were not at fault. We do not know the nature of the difficulty with the ion-getter pump. It was necessary to put back on the system the vacuum pump that had been displaced by the ion-getter pump. At present, we use the regular vacuum pumps and close off the ion-getter pump while operating; at night and over weekends we use the ion-getter pump.

Fabrication was completed of the device for producing doubly charged helium ions for use with the Van de Graaff.

One of the precision long counters was loaned to Mound Laboratory so they can compare theirs with it.

A Simpson Pile, a monitor for cosmic ray neutrons, was constructed to be used to detect variations in background neutron fluxes during future measurements.

An AEC Fellow on assignment investigated the possibility of employing a theorem of Garwin (Rev. Sci. Inst. 23 755 (1952)) in constructing a special

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scintillation counter that might be used in neutron work. It apparently cannot be used. The theorem concerns transmission of light in light pipes. Apparently we cannot get the required high degree of reflectivity required for application of the theorem.

Filings from the Sb-124 source used in our half-life measurements were sent in for mass spectrographic analysis. The purpose is to detect any contaminant Sb-125 that may be present.

An addition to the gamma ray calorimeter was designed that is intended to reduce or eliminate the small heat leakage found recently.

The solid state neutron spectrometer utilizing Li-6 that was obtained recently was used in measurements at the PCTR to investigate its possible usefulness for spectrum measurements in a reactor. With the device placed against a fuel element and with the PCTR operating at 0.1 watt spectra were obtained which showed clearly the thermal and fast neutron parts of the spectrum. At power levels a few times this, the counting rate became so high and the gamma ray pile-up so bad, that the spectra were seriously distorted. So much cadmium was required to shield the device from thermal neutrons that it appeared to alter the spectrum in the reactor where the device was located. This experiment was done at the request of Non-Metallic Materials Development Operation.

Radiation Instruments

Development and fabrication was completed on a third pocket-type sensitive signaling dose meter. The two original prototype units, one of which incorporates only register readout and the second which incorporates binary circuits to provide both visual and audible indications as selected, were demonstrated to HAPO radiation protection personnel. A decision was reached to simplify the dose meter design to provide only an audible signal following an accumulated dose of 50 mr. Later models may be set at 100 mr for certain applications. The third prototype satisfies the new requirements, and has tested satisfactorily to date. Final design effort was continued to eventually provide units of the selectable level signaling and visually-indicating type for anticipated specialized plant needs. All of the forestated dose meters use automatic recharge type pencil dosimeters as sensors, and all circuitry is transistorized.

A fourth experimental dose meter of the high level type, 5 r to 100 r, was completed in first generation form, tested, and demonstrated to HAPO radiation protection personnel. This unit, which provides a selectable-level signaling trip point, uses only audible signaling when the preset accumulated dose is reached. It uses a standard pencil

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dosimeter as a sensor and has an electrometer tube and transistor circuits. All power is supplied by incorporated batteries, and no charging from an external source is required. This type of dose meter, which tested correctly from 0°F to +130°F, has potential applications in nuclear accident monitoring and civilian defense.

An invention disclosure was filed on a possible capacitance method for detecting the position of the fiber in a signaling dose meter electroscope.

A number of tests were satisfactorily completed following circuit modifications on the experimental prototype six decade (three decades per scale with automatic scale switching) logarithmic response scintillation transistorized radiation area monitor. Stable, satisfactory dc alarm trip circuits were developed and tested. Temperature tests of the complete system including probe, cables, and instrument showed errors based on full-scale output meter current to be less than $\pm 1.5\%$ from 0°C to +65°C. This equates, on either three decade log scale, to actual reading errors of about $\pm 10\%$. Similar errors were noted with the instrument at room temperature and with only the probe exposed to the 0°C to +65°C variation. The alarm trip point stability was identical to the values stated. The determined circuit changes will now be incorporated permanently in both the log response and the combination log and linear response prototype monitors.

Circuitry changes to incorporate a rechargeable nickel-cadmium battery were completed on the experimental transistorized G.M. portable instrument, which has both count-rate meter and aural indication of counting rate.

A new light chamber was designed and fabricated for use in the continuous or real-time airborne zinc sulfide particle monitor being developed for use in atmospheric air movement and diffusion studies. The chamber is located between the multiplier phototube and the ultraviolet light which is used to activate the ZnS particles. Although tests are not complete, improvement in detection sensitivity was noted.

The commercial wind speed and wind direction transducers were received for use in the experimental Atmospheric Physics portable mast system.

The incorporated semiconductor preamplifiers of the wind speed unit were unsatisfactory and new transistor circuits were developed, tested, and installed. The modified transducer performed correctly from 0°F to +150°F; however, after continued operation at +150°F, the apparently highly-stressed aluminum anemometer cups flattened out and were destroyed. Interference or cross talk tests were made with the preamplifier and 500 feet of small cable using 560 ohm termination. The signal-to-crosstalk ratio was determined to be about 37 decibels. This is satisfactory especially since only simple

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low-pass filtering will be additionally required to eliminate high frequency pickup noise. The developed preamplifier output voltage signal level is about two volts peak-to-peak.

Experiments continued regarding various methods of simplified readout and data utilization for coincidence-type alpha air filter counters for 4 inch x 8 inch standard filters. Following considerable actual tests with a large number of filters, a pre-set count method was developed to provide simple and reliable evaluation of data. This approach, which is superior to the usual pre-set time method, requires the operator to only have to determine one number if the filter is contaminated instead of having to plot results on a graph. Measurements with a special fabricated disk source of Pu^{239} and $\text{Sr}^{90}\text{-Y}^{90}$ indicated an instrument resolving time of 0.1 milliseconds. With this and the extensive test data from the 500 filters, the random coincidence rate, which injects an error in the coincidence channel, should not exceed 6%. Since the filter is removed from its location to be counted, the alpha-to-coincidence count ratio will slowly change with time. With the stated variables taken into account, the system can still detect 2000 d/m of Pu^{239} in the presence of extremely large concentrations of radon-thoron. This sensitivity equates to 1 MPC (2×10^{-12} $\mu\text{c/cc}$) of Pu^{239} for a 23 hour flow of 10 CFM.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis Program

Isotopic analyses were provided on program samples as received during the month. The results of daily analyses of uranium standard samples showed no change in the value of the systematic bias in mass ratio reported during July.

The solid-state alpha-particle spectrometer has been placed into routine service to assay sample filaments to determine the fraction of sample actually loaded onto the mass spectrometer filament. The poor pulse-height spectrum previously reported for this device was determined to be due to an insensitive surface layer of about 115 kev equivalent thickness (for 5.5 Mev alphas) combined with the necessary filament-counting geometry.

TEST REACTOR OPERATIONS

PCTR Operation

The PCTR was operated intermittently during August with one unscheduled shutdown resulting from electronic failure. Measurements were made during the month to aid in the design of the proposed High Temperature Lattice

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Testing Reactor. Several reactor runs were made to provide neutron flux for testing a developmental solid state neutron detector. The work was requested by Non-Metallic Material Development Operation. The permanent thermal column was installed on top of the PCTR. Part of the month was devoted to minor maintenance items.

TTR Operation

The TTR was not operated during the month.

The second two zone experiment for 1.8% Pu-Al fuel in a 0.85 inch lattice was completed in the critical approach tank.

CUSTOMER WORK

Weather Forecasting and Meteorological Service

Consultation service was rendered on meteorological and climatological aspects of 1) oxides of nitrogen release in 300 Area to IHO for FPD, 2) phosgene release in 200W Area to IHO for CPD, 3) distance criteria for industrial development in the vicinity of 300 Area to RPO, and 4) low altitude aircraft sampling for fallout to CR&D.

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

Weather Summary

<u>Type of Forecast</u>	<u>Number Made</u>	<u>% Reliability</u>
8-Hour Production	93	85.4
24-Hour General	62	87.3
Special	161	91.9

August averaged somewhat cooler than normal. Although precipitation was 2-1/2 times the normal, there were only three days with a measurable amount.

Instrumentation

The Automatic Conveyor-Type Alpha-Beta-Gamma Laundry Monitor successfully performed during a series of fully-operational tests at the HAPD Laundry Facility. All portions of the system performed correctly. The automatic loading system performed well, but needs a few corrective adjustments.

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Tests are continuing to determine the proper rejection level settings for alpha and beta-gamma contamination. Routine operation is expected shortly and an extensive, detailed operation and maintenance manual is nearing completion in rough-draft form. Most of the detailed circuit diagrams have been completed.

Calibration adjustments were completed on the five transistorized scintillation beta-gamma fission product air monitors for Radiometallurgy Laboratory, 327 Building. Four units were installed for fixed-location operation and the fifth unit will be operated in a semi-portable fashion. All units have performed correctly to date. They were adjusted to energize the alarm if an airborne mixed fission product concentration of 1×10^{-9} $\mu\text{c/cc}$ (one MPC) exists for 25 minutes with a 15 CFM airflow rate. Fixed source tests indicate the alarm will energize for 2.4×10^4 d/m $\text{Sr}^{90}\text{-Y}^{90}$. Since the slope of the curve on the chart recorders provides a measure of the rate of deposition on the filter, the fission product air concentration can be estimated for any short period as desired.

Approximately 500 actual sample air filters from the 308 Building were counted during the month on the prototype coincidence-count alpha air filter counter, which was designed for Radiation Protection Operation to provide immediate counting of standard HAP0 4 inch x 8 inch air filters without waiting for radon-thoron decay. The instrument will be installed after the operation and instruction manual is completed.

Laboratory tests continued on the field model continuous coincidence-count alpha air monitor as fabricated for Radiation Protection Operation. Long-period tests are necessary to provide adjustment information from data obtained during high level radon-thoron atmospheric conditions. General operation of the monitor has been satisfactory to date.

Design and development continued on two specific instruments for Finished Products Chemical Technology, CPD. The first is a plutonium fluoride weight detector to be used in Hood Nine, 234-5 Building. Design to date considers a sealed balance system which will activate a very sensitive microswitch when a specific amount of powder rests on the balance pan. The second instrument, to be used in the same location, has been completed and is a conductivity monitor used, in essence, to determine caking of plutonium fluoride powder due to increasing moisture content. The instrument is transistorized, 110 VAC operated, and operates in a fail-safe mode. A trip signal for high conductivity, which indicates excessive caking, is indicated by a lamp and by closing relay contacts which can be used for an external alarm. The sensor consists of two stainless steel wires properly spaced and mounted in the Hood Nine facility.

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The airborne sensitive transistorized scintillation gamma survey instrument, designed for and in use by Radiation Protection Operation, was modified to use a 12 volt rechargeable nickel-cadmium battery and a 12 VDC energized DC-DC converter high voltage supply. Continuous operation for 80 hours is possible, and the addenda battery charger will recharge the battery overnight. Operation has been fully satisfactory.

A two-section alarm system was designed and tested for use with the scintillation transistorized Columbia River Monitor which was designed for and is in use by Radiation Protection Operation. One portion of the unit will be installed at the river and the second remote indicator section was installed at the Patrol desk, 3701-L Building. The remote unit provides indications for normal operation, low-level trip, high-level trip, and general power failure. Audible and visual signals are provided, and a test unit was included to provide periodic testing. In addition, a delay circuit was designed to prevent damage to the main river water pump from possible line voltage variations following an outage.

Calibration of micro-displacement readout systems to be used by Physical Metallurgy Operation for in-reactor creep measurements continued. The basic calibration of the transducer system used in the third generation creep capsule is approximately 80% completed. This calibration was considerably delayed this month due to repeated failures of the DC-DC converters used for transducer excitation and demodulation. Because of these failures, the ambient temperature effect tests have been cancelled. The test series to determine the effect of varying the zero control settings will be conducted as originally scheduled, however.

Instrumentation work for the Radiation Effects Facility at 100-KW included installation and testing of a prototype micro-positioner digital control system for use in creep capsule tests, and a visit to a vendor's plant to resolve problems and obtain information on the expansion capsule data logging system.

Consultation was given Quality Control Engineering, FPD, in the selection of a system to read out on punched paper tape the dimensions of NPR fuel elements to be tested under the Pre-Irradiation Measurements program.

Preliminary development was carried far enough to permit QCE to begin procurement of the system components. The readout device will be similar to the 306 Bldg. installation, but will incorporate several design improvements. This is the fourth fuel element readout to be based on our initial design.

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Optics

A developmental model electrical readout process tube traverse mechanism was tested and calibrated. The unit yields data which are reproducible to within 0.005 inch. This is about the same reproducibility obtained with a previously demonstrated optical unit. The data permit distortions in an eight foot length of tube to be calculated with an accuracy of ± 0.080 inch. An operational unit is now being designed for use in NPR. A similar unit can readily be built for use in the old reactors.

During the six-week period (July 22-August 31) included in this report, a total of 560 man hours shop work was performed.

The work included:

1. Fabrication of 20 glass bearings for CPD.
2. Repair of two crane periscope heads for B Building and Redox crane periscopes.
3. Aluminizing four mirrors and one bell jar.
4. Fabrication of 50 pyrex wheels for FPD.
5. Fabrication of an aluminum sphere for Experimental Nuclear Physics Operation.
6. Assembly of a profilometer stylus for FPD.
7. Repair of borescope and TV camera lens for Structural Materials Development, HLO.
8. Preparation of two scintillation reflectors for Experimental Nuclear Physics Operation.
9. Preparation of three glass scintillation wafers for Finished Products Chemical Technology, CPD.
10. Lapping of two test blocks flat to 10 microinches for Finished Products Operation, CPD.
11. Fabrication of six film holders for Radiological Development and Calibrations, HLO.
12. Repair of one microscope for Radiometallurgy Operation.
13. Preparation of nine LiF targets for Radiological Physics Operation, HLO.
14. Fabrication of components of a photometer for Chemical Development Operation, HLO.
15. Repair of three camera shutters for Metallography Labs.

Physical Testing

A total of 5,058 tests were made on 4,547 items with an aggregate of 44,804 feet of material. Testing requirements appear to be remaining steady, with the greatest footage consisting of tubular components. Work

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was done for a wider variety of customers this month; some 31 different HAPO components representing most of the operating department and service organizations and other AEC contractors were serviced. Advice was given on 48 different occasions on general testing theory and applications.

Kaiser Engineers have completed their work on NPR process tubes and have permanently vacated their work stations in the White Bluffs facility. Sufficient tubes were tested and treated to complete installation in the reactor and to provide an initial lot of spare tubes. A small number of tubes which are being reworked by the manufacturer will require testing and treatment by Physical Testing later.

With the completion of NPR process tube work, testing of the remaining PRTR spare process tubes has proceeded. All tests have been completed on the tubes except for six tubes remaining to be pickled and autoclaved.

Minor equipment modifications of the tube facilities have been initiated preparatory to testing K-reactor Zircaloy replacement tubes. The first shipment of tubes is scheduled for mid-October.

Eddy current testing of 150,000 feet of 1/4" O.D. Inconel instrument tubing was completed. Complete analyses of results are not yet available, pending determinations of hydrostatic failure tests; however, evidence of confidence in the test is good. About half way through the program, the customer decided to use the eddy current test in lieu of the originally specified hydrostatic proof test; however, contractual problems need to be resolved before this cost saving step can be effected.

F-Reactor Operation was assisted on an emergency basis to evaluate a horizontal control rod replacement. A radiographic examination was made to establish positively whether the rod was a half-rod or a full rod.

Tests were made for two bid acceptance evaluations for Process Design Operation, IPD. The samples involved were stainless steel chain weld specimens, and stainless steel swage lock connector fittings. Integrity of the welds and effectiveness of the seals were determined by micro polishing, etching, and photographing the specimens.

The results of tests performed for FPD on two problems may have potential for production application. Fuel element support clips for I&E fuel elements were cracking when formed into shape. A test was needed to reliably detect and evaluate the severity of the cracks. Radiography was tried with good results; however, the precise alignment of each clip needed to accurately measure the depth of the cracks precluded production application. A fluorescent penetrant test was also tried although the

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customer had previously tried it with unsatisfactory results. A demonstration was made to elaborate on the controls necessary for a successful test including choice of penetrant, penetrant time, emulsification time, washing, and read-out. With proper controls, the fluorescent penetrant method was shown to be useful for this problem. A cladding problem on enriched uranium fuel elements with Zr cladding was attacked by autoradiography. Use of standards of known wall thickness, optimum film selection, and automatic film processing yielded results of consistent uniformity with good detail. Resolution of cladding variations appeared to be greater than the customer could achieve with ultrasonic methods.

A new ultrasonic rail flaw detector purchased by the Track Maintenance Operation of CE&UC was checked out, a set of standards fabricated, and instructions prepared for the proper use of the instrument.

Ultrasonic testing work aimed at finding a method for in-service monitoring of the primary loop piping of NPR continued. Evaluation of ultrasonic results on fatigue specimens was completed. The results indicated: a positive correlation with discontinuity location and size; focusing of the second beam due to pipe curvature; observation of discontinuity "growth"; and observation of surface crack formation. A pressure vessel made from a piece of NPR piping was cyclically tested to failure at Southwest Research Institute. The failure pattern substantiated the findings indicated above as it occurred at a location on the longitudinal weld seam where we had found strong ultrasonic indications of discontinuities.

Calibration of accelerometers for measuring vibration of PRTR reactor tubes and piping was completed. Two tri-axial accelerometers showed amplitude discrepancies between axes which were of a greater magnitude than desired and may have been caused by vibration table error. Samples of various types of insulated mounting materials were evaluated. Linen phenolic was selected and mounts for the accelerometers were fabricated. All of the equipment needed for the vibration testing is now ready.

Analog Computer Facility Operation

The major problems considered during the month were:

1. Reactor Transfer Function Studies.
2. PRP Critical Facility.
3. PRTR Nuclear Excursion Studies.
4. Optimization Techniques.

Further study was made of the simulation of the cylindrical heat transfer problem reported in Systems Research Memorandum 62-25. The initial analysis

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of the runs made indicated that at a distance of 200 feet the temperature has dropped to about one percent of the temperature of the first node, and only 10 nodes are necessary for this particular simulation. Results of runs will be evaluated as soon as time permits.

A program for the same problem was written for the IBM 7090 computer. The results were not in agreement with the analog simulation results. Analysis showed some difficulty arising from an approximation. A reformulation was done and a rewriting of the problem will be attempted during next month.

The parts for a special noise amplifier to be used in the testing of computer-tube cathode condition were received early this month and the amplifier was constructed and checked out. In order to set up operating conditions for testing, tubes which failed in the analog computers were secured and measured. Out of 62 tubes (type 12AX7) which failed on the EASE computer, the noise test picked 50 as faulty. If one considers that for 19 of these faulty tubes no obvious trouble could be found (except that they did not work in the computer), the noise test shows a good potential.

Eighty-eight percent of the GEDA equipment and ninety-five percent of the EASE equipment was in good operating condition during the month. Computer utilization was as follows:

<u>GEDA</u>	<u>EASE</u>	
155	155	Hours Up
25	25	Hours Scheduled Downtime
0	0	Hours Unscheduled Downtime
0	0	Hours Idle
<hr/>	<hr/>	
180	180	Hours Total

Instrument Evaluation

Thirteen Model II Scintrons of 65 total fabricated off-site in Seattle have been completely tested and ready for routine field use. To facilitate maintenance, all Model II Scintrons will be serviced in the Portable Instrument Shop.

All wiring errors and incorrect parts were corrected on two on-site fabricated scintillation, transistorized alpha hand counters. All tests have been completed and the instruments are ready for field use.

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The logarithmic and multi-decade linear response scintillation transistorized radiation area monitor was installed in the 326 Building on August 8 following evaluation completion. Performance to date has been satisfactory.

The blueprints and purchase specifications were upgraded for the standard Hanford C-P portable dose rate instruments.

All thirty of the transistorized portable BF₃ neutron detecting instruments, as fabricated off-site, have been tested and are satisfactory. The small BF₃ tubes, which are to be fabricated on-site, have not been completed to date.

One more scintillation transistorized portable alpha "poppy" instrument will be fabricated by the Portable Instrument Shop to check a new layout and battery substitution. The first generation prototype continues to perform satisfactorily.

All evaluation tests were completed and reported on a Nuclear Measurements Corporation Model GA-2A Radiation Monitor of the scintillation, vacuum-tubed circuit type. The evaluation was requested by Facilities Engineering, FPD.

Seven scintillation transistorized combination alpha-beta-gamma hand, shoe, and clothing monitors are being fabricated in Seattle on an order from Radiation Protection Operation. In order to provide more exact pulse height data needed, additional tests were performed on the scintillation alpha-beta-gamma probes which employ only an air, reflector-type, light pipe. Optimum high voltage operational levels were determined for the incorporated RCA 6655-A multiplier phototubes. The scintillator for the hand probes is a 4 inch x 8 inch sheet of 0.02 inch thick terphenyl-in-polyvinyltoluene coated on the hand side with about 10 to 15 mg/cm² of zinc sulfide (silver activated). The ZnS is for alpha detection and the other for beta-gamma detection. The light shielding material is two layers of 0.2 mg/cm² aluminum "dutch" leaf covered by one layer of 0.9 mg/cm² double-aluminum coated Mylar. During the same procedural tests, an EMI-9536-B phototube was also checked; however, for this particular application, the less expensive RCA 6655-A tubes performed as well. It was determined that either phototube gain or transistor amplifier sensitivity could vary by $\pm 10\%$ with retention of a satisfactory signal-to-noise ratio.

Special enamel coatings were evaluated for use on the various hand and shoe counter hand probe wire screens to prevent hand injury. The coatings

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of "Nu-Pon Cote" were excellent, and the process will be used on all future hand monitoring scintillation probes.

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Manager
PHYSICS AND INSTRUMENT RESEARCH
AND DEVELOPMENT

PF Gast:RSP:mcs

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CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 02 PROGRAM

IRRADIATION PROCESSES

Reactor Effluent Water Radioisotope Studies

Deionized water has been passed through a new tube containing new fuel elements in KE reactor, and Ga-72 concentrations in the effluent from this tube have been compared with Ga-72 concentrations in the effluent from a control tube utilizing high alum feed water. The Ga-72 concentration in the deionized water was more than twice that from the control tube, indicating that the source of Ga-72 in reactor effluent water is impurities in the aluminum, and that Ga-72 determinations in effluent water might be used to measure corrosion rates in new aluminum.

In order to verify that isotope reductions noted from silicate additions were due to added silicate and not to the higher pH of the silicate-containing water, a sodium hydroxide addition is being made to a tube in KE reactor at pH 7.00, relative to 6.60 for the control tube. The pH of the previously added silicate water was also 0.40 units higher than the control tube. After nine days of addition, Na-24 and Mn-56 activities in the test tube were increased by factors of about 0.5 and 0.6, respectively, but As-76 and Cu-64 activities were essentially unchanged. For this sodium hydroxide addition the effects, if any, on Np-239, Cr-51, P-32 and Zn-65 activities are also being determined. A second sodium hydroxide addition at pH 7.50 relative to 6.60 for the control tube is scheduled for September.

Ground Water Temperature Studies

Ground water temperatures changed only slightly in the region between and encompassing the 100-H and 100-D Areas. No cold river water was detected moving inland to this region during the recent high river stage. In a region just south of the 100-H and 100-D Areas there is a sector, approximately two square miles in extent, in which the ground water temperatures fluctuate from two to five degrees centigrade over a six-month period. In view of the fact that no river water can be detected moving into this general region to cause such changes, it is probable that the

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fluctuations are brought about by changes in the air temperature from season to season. A temperature lag of six months might be expected where the depth to the water table is between 20 and 30 feet as it is in this region.

Treatment of NPR Decontamination Wastes

Laboratory experiments were conducted with dibasic ammonium citrate waste containing the complexing agent triethanolamine at 85 C, the waste temperature after collection in the NPR waste treatment tank. Previous experiments, at 25 C, indicated adequate scavenging of Co-60 and other radionuclides could be obtained by adding ferrous sulfate to a Fe^{+2} concentration of 400 ppm following by sodium hydroxide addition to pH 11. Scavenging of Co-60 was greatly improved at the higher temperature. More than 99 percent of the Co-60 was removed at 85 C between pH 10.5 and 12.5 in contrast to only 80 percent removal at 25 C in a slightly narrower pH zone. These results indicate that 400 ppm Fe^{+2} is not only an ample concentration for treatment of this waste, but even less iron might provide adequate scavenging. Control of the NaOH addition does not appear to be as critical as was indicated at the lower temperatures. Addition of sodium hydroxide to an initial pH between 12.0 and 12.5 would insure the waste remaining above pH 11 despite the reduction in pH level noted after maintaining the temperature at 85 C beyond a few days.

Characteristics of NPR Decontamination Wastes

Laboratory research was aimed at solving problems associated with the collection and ground disposal of NPR decontamination wastes. The scavenged citrate waste supernate was readily transmitted by soil at a rate 87 percent that of water. No evidence of soil plugging was indicated.

Waste frothing, a problem encountered during mixing, was controlled in both the citrate and multi-step wastes by the addition of a silicone antifoam agent to 100 ppm. At this concentration the effect of antifoam agent on soil permeability was negligible.

The reaction which occurs between alkaline permanganate and peroxide bearing carbonate solutions evolves oxygen with a potential for excessive pressure in the waste collecting tanks. Under simulated conditions spontaneous decomposition of the hydrogen peroxide occurred at 50 C and was virtually complete at the end of two hours. Calculations based on these results indicated that pressures likely to be encountered in the waste collecting tanks as a result of this reaction will not exceed one psi.

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Calculations based on estimates of the radionuclide concentration in waste sludge indicate that excessive self-heating of the waste by radioactive decay will not occur.

Efficiency of Charcoal in Reactor Confinement Halogen Traps

Further examination of charcoal samples from reactor confinement iodine traps showed molecular iodine retention of greater than 99 percent. Previously unexposed charcoal and samples supported in the reactor ventilation exhaust since completion of the confinement project were compared. No significant differences in efficiency were found. The presence of adsorbed I-131 on the charcoal sample from one reactor indicated that iodine in the 105 Building ventilation system was being collected on the charcoal.

SEPARATIONS PROCESSES

Iodine Removal Processes

Aerosols were generated and introduced into air atmosphere containing I-131 to determine whether the iodine could be condensed on the particulates and be filterable. An attendant purpose was to determine whether charcoal would adsorb iodine under these conditions. Iodine in an atmosphere of fine water droplets was efficiently removed in a charcoal trap. Aerosol formed from sparking copper in air appeared to associate with the iodine since a charcoal trap did not retain the iodine present. Tungsten smoke increased iodine retention on membrane filters from 3 percent to 13 percent.

Electrochemistry of Plutonium in Molten Chloride Salt Solutions

Studies of the electrochemistry of the electrolytic reduction of PuCl_3 to plutonium metal in molten chloride salt solutions are well under way. In one series of experiments, using a molten plutonium cathode and a melt comprised of PuCl_3 in 55 m/o KCl - 45 m/o BaCl_2 , a second salt phase was found at the end of the electrolysis. This second phase, which contained most of the plutonium, appeared to be a compound of plutonium in a lower oxidation state. From preliminary analytical data, the compound could have the composition $2\text{BaCl}_2 \cdot 3\text{PuCl}_2$. In two other runs made under nearly the same conditions (a horizontal tungsten sheet cathode in place of plutonium) but carried out for longer times, the melt appeared to be completely depleted of any plutonium compound. Again, no massive plutonium metal deposit was formed, but only tiny nodules dispersed in a thin, black-colored layer just above the surface of the cathode.

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Purex Process Studies

Efforts to characterize and determine the source of water impurities in the Purex uranium second cycle system have been continued. A methanol extract of the material retained by the glass fiber water filters was evaporated to dryness and extracted with ether. The resulting extract was evaporated to dryness, yielding a solid which analyzed 47.1 percent C, 8.23 percent H, 4.69 percent N, 1.90 percent S, and 1.50 percent ash. The material not extracted by ether analyzed 45.3 percent C, 7.4 percent H, 1.6 percent N, 0-trace S, and 7.61 percent ash. The amount of sample unaccounted for is high, approaching forty percent in each case. Chlorine control (analysis forthcoming) is expected, therefore, to be appreciable.

Characteristic tests have shown the filter material to contain organic amines, carboxylic acids, and hydrocarbon "greases." The large pieces of inorganic appearing material found on the filter probably come from the aluminum storage tanks; the precipitates building up as a result of fluctuating pH in the systems. Solid particles from the water filters contained, by emission spectroscopic analysis, > 1 percent Si; 0.1 - 1 percent Al and Fe; 0.01 - 1 percent B, Cr, Cu, Mg and Ni; ~ 0.01 percent Mn and Ag; and < 0.01 percent Ti.

Analyses of residues obtained from cation exchanger influent and effluent, anion exchanger effluent, and filter effluent show the following:

1. The cation exchangers are removing much but not all of the metallic impurities
2. The anion exchanger is quite ineffective; both chloride and sulfate are found in the effluent.
3. Low anion exchanger efficiency is confirmed by the low pH (< 5) which is measured in the effluent after nitrogen sparging the CO₂.

Reaction of these various water samples with permanganate indicated the addition of oxidizable material upon passage through the cation exchanger and, to a lesser extent, through the anion exchanger. (This suggests the possibility of adding KMnO₄ as a water treatment agent.)

The evidence to date tends to the conclusion that the ion exchange resins are responsible for some of the organic matter found on the filters. Whether these alone are responsible for the effect on transfer rates is unknown.

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Diether Studies

Approximately 100 grams each of 1,4 diethoxybutane and 1,5 dimethoxy-pentane have been prepared. These materials will be tested in Redox type process applications.

Denitration of Purex 1WW With Formaldehyde

Foaming, a symptom of the plant unit, was produced in the pilot plant unit by the addition of 0.4 gram of DBP per liter of 1WW. The amount of foam was found to increase as pot temperature and formaldehyde addition rates were increased. At high temperatures and flow rates, the foam height reached a maximum of over six feet above the pot overflow - 14 inches into the tower packing. Under similar conditions the addition of 0.2 grams per liter of silicone antifoam reduced the foam level two-fold.

An equilibrium run made to determine nitric acid destruction and formaldehyde utilization indicated that two to three percent of the initial formaldehyde escaped to the product without reaction and that about 2.6 moles of nitrate were destroyed per mole of formaldehyde fed.

Resin Stress Measurements

Measurements were made of radial and vertical stresses in a bed of 20-50 mesh glass beads moving co-currently and counter-currently to fluid. Results for the radial stress were similar to resin beds except for a region extending about 1.7 bed diameters up from the support screen. In this region the internal friction of the particles was sufficient to markedly reduce the radial stress due to the constraining effect of the support screen. Beyond this point the radial stress followed the force-balance relationship closely. The ratio of radial-to-vertical stress was about 1.5 as compared with a range of 0.7 to 1.2 for various sized resin particles.

WASTE TREATMENT

In-Tank Solidification

A document, HW-74371, summarizing laboratory studies to date on in-tank concentration of coating removal waste was issued this month.

In previous studies, solutions simulating "old" coating removal wastes were used. Because of process changes, "current" coating

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removal wastes have a significantly different composition. The NaOH/Al ratio and the sodium nitrate concentration are lower in the current waste. Concentration characteristics of simulated current wastes were studied. Considerably more water must be removed from current waste than from old waste before a concentrate which will solidify completely at room temperature or above is produced. Concentration factors necessary to produce residues which would solidify completely on cooling were in the range 7-8 for the current waste compared to about 4.5 for the old wastes.

The coating waste supernate remaining after the last pilot plant simulated solidification run has been solidified by the addition of about 65 percent by weight of sodium bicarbonate. Reaction is rapid and complete at temperatures ranging from ambient to 105 C. Calcined plaster of paris was also effective in solidifying the same type of supernate. When 50 percent by weight was used, the setting action required about three minutes to be complete and when 33 percent by weight was employed about three hours were required. Analysis for amount of free caustic has not been completed. Solutions of laboratory sodium hydroxide behaved in identical manner.

Ultrasonic Depth Sounding of Waste Storage Tanks

A 200-kilocycle transistorized depth sounder was tested in an experimental tank containing simulated Purex 241-A waste supernate and sludge. The depth sounder had two major faults which make it unsuitable for the proposed application. First, the transmitted pulse width was found to be two milliseconds; this relatively long pulse time results in the reflected pulse from the top of the sludge layer blotting out the reflected pulse from the tank bottom. Also, the instrument has a minimum range of 0 to 120 feet, which means it would be operating only over a narrow fraction of the chart reading. A 60-kilocycle instrument is now being procured which is expected to be more adaptable to the task of determining sludge depth and bottom contours of waste storage tanks.

Cesium Removal from Formaldehyde-Treated Waste

Results of a clinoptilolite column experiment with zirconium-niobium traced FTW indicate that zirconium is only slightly sorbed by the mineral while most of the niobium is sorbed even beyond cesium breakthrough. A 0.5 M oxalic acid wash removes the zirconium in less than three column volumes and > 90 percent of the sorbed niobium and sodium in seven column volumes.

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Column studies with Linde AW-400 inorganic ion exchanger indicate that 250 column volumes of FTW (130 gal/t U) brought to pH 3.5 with lithium hydroxide and citric acid could be processed to two percent cesium breakthrough and 350 column volumes to 50 percent breakthrough. Flow rate was five column volumes/hour and particle size was 20-50 mesh. With the same exchanger and a 1:1 dilution of synthetic Purex neutralized supernatant waste, 90 column volumes were passed to 50 percent breakthrough. These results indicate both greater selectivity and better kinetics for AW-400 than for clinoptilolite. However, the synthetic exchanger is not stable in 0.5 M nitric or oxalic acids. Alternate flow sheet steps for use with this material are being studied.

Strontium Packaging

Engineering scale experimental studies on the loading of strontium on 1/16-inch pellets of Linde 4A were continued. At a feed rate of 1.5 gpm/cu.ft. a 50 percent breakthrough was reached after 10 column volumes were processed at ambient temperature. Reduction of the feed rate to 0.4 gpm/cu.ft. allowed about 25 column volumes to be processed to the same breakthrough. These pilot plant data indicated that the Linde 4A loading kinetics in the particle diffusion region of strontium concentration (> 0.05 M Sr^{++}) are very slow at ambient temperature and for this particle diameter.

Laboratory experiments were conducted to evaluate the effect of particle size and temperature on the loading rate of strontium product solution. A flat breakthrough curve reaching 50 percent strontium breakthrough at 9 column volumes was obtained with 1/16-inch pellets of Linde 4A, confirming the pilot plant data. A column experiment with the same feed but with 0.4 - 0.7 mm Linde 4A confirmed earlier laboratory data with a steep curve and 50 percent breakthrough at 31 column volumes. Increasing the temperature from 29 C to 65 C with the 1/16-inch pellets increased the slope of the curve somewhat and gave a 50 percent breakthrough volume of 17 column volumes. Since Linde 4A is commercially available in grain sizes down to 50 mesh, kinetic problems do not appear to be serious.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Improved Purex Head-End Strontium Flowsheet

Two hot-cell runs were completed during the month to test the peroxide process (which employs peroxide-tartrate complexing to

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hold rare earths in solution during strontium sulfate precipitation). Performance with full-level LWV was disappointing, compared to tracer-level experiments with synthetic solutions. Whereas tracer runs had given 95 percent strontium recovery and a decontamination factor of about 5 from cerium, only 75 percent strontium recovery and a DF of 2 from cerium and promethium was observed in the first run. The precipitate was also more voluminous than normal, implying that some of the iron precipitated. Hydroxylamine was added in the second run to minimize radiation-induced oxidation of the complexant (produced by action of peroxide on tartrate). Ninety percent of the strontium was recovered and the precipitate was not voluminous; however, the DF from cerium and promethium was still only 2. Supporting tracer-level laboratory studies suggest that more satisfactory performance should be obtained at higher pH (3 vice 2) and perhaps at lower temperature (25° C vice 50° C). Additional hot-cell runs will be made in the near future to test these variables.

Precipitation Recovery of Cesium from Purex Tank Farm Supernates

Additional hot-cell runs were carried out to optimize conditions for an early plant test of the nickel ferrocyanide process for precipitation of cesium from Purex tank farm supernate (in behalf of Hanford Waste Management). In earlier hot cell runs, degree of cesium precipitation (98 percent) was quite satisfactory but material balances were unsatisfactory, due to mechanical handling characteristics of the cesium precipitate, much of which was left in the feed tank or centrifuge. Although it is unlikely that this will be a problem in the plant equipment (the feed tank is equipped with an agitator and the centrifuge with high pressure sprays), two runs were made with a "dissolvable filter aid" to increase the bulk and improve the slurrying characteristics of the precipitate. Calcium nitrate was added to the feed. The calcium precipitated along with the ferrocyanides (probably a calcium carbonate). Subsequent addition of acid to the centrifuge dissolved the calcium and efficiently slurried the cesium precipitate from the centrifuge bowl. Over 90 percent overall cesium recovery (through the final metathesis operation) was obtained, with the balance left in the feed tank, centrifuge, lines, etc. Decontamination factor from sodium and potassium was about 100 and from rubidium about 5.

Sucrose Treated Waste (STW)

Because of the difficulties which have attended the use of formaldehyde treatment in the Purex plant, other organic compounds have

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been tested as reagents for the destruction of excess nitric acid. Several (notably citric, oxalic, and tartaric acids) are effective in the presence of radiation. Sugar (sucrose) reacted with the nitric acid in synthetic LWW at an appreciable rate even in the absence of radiation. Laboratory experiments show that the reaction is catalyzed to some extent (two-fold acceleration) by the salts (probably iron) present in LWW and that the rate is strongly temperature dependent. Unlike the formaldehyde-nitric acid reaction, the sucrose reaction does not appear to be significantly exothermic or to have an induction period. The reaction is easily controlled by choice of temperature, even when all of the sugar is added at the beginning of the experiment (which would not normally be done, except by accident). Fifteen to twenty moles of nitric acid are destroyed per mole of sugar consumed, which makes the cost of sugar and formaldehyde approximately competitive. If the inherent safety of the sucrose reaction is borne out in large-scale tests, it should be possible to "kill" nitric acid in any conveniently sized plant tank which is equipped with a reagent addition line and a heating coil. A reflux column is not required, and little or no benefit was observed when one was used, at least in small-scale equipment.

In addition to the laboratory experiments with synthetic solutions, hot-cell experiments were run with half to one-liter quantities of full-level plant LWW. To simulate a worst possible case, all of the sugar was added initially and the solution quickly brought to a boil. Evolution of oxides of nitrogen (NO_2) was initially vigorous, but controllable, and there was little or no tendency to foam. The nitrate concentration was reduced from 5.3 M to 1.06 M in 2-1/2 hours. No precipitates, tars, or chars were observed in any of the experiments.

Composition of the off-gases evolved (presumably NO_2 and CO_2) and identity and concentration of organic compounds (if any) left in the solution are being determined. On the basis of the data thus far obtained, larger-scale cold testing appears warranted.

Radiolytic Gas Evolution from LWW

At the request of Purex Technology, the rate of gas evolution from a 200-gallon cask of centrifuged Purex LWW (obtained for A-Cell calciner studies) was measured and the composition of the gas analyzed. A null point manometric method was employed. Average rate was 610 cc/hr, which is equivalent to 0.15 cc per watt hour. This may be compared to values in the range 0.5 to 1.2 cc per watt hour observed some time ago for casks containing strontium and/or

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cerium-promethium feed solutions. Reason for the order-of-magnitude difference is not known. Composition of the gas evolved from the 1WW cask was: 40 percent CO_2 ; 43 percent H_2 ; 10 percent N_2 ; 7 percent N_2O , NO , NO_2 ; 0.1 percent A ; and 0.1 percent O_2 .

Plutonium Recovery from 234-5 Oxalate Supernates-Resin Stability Studies

An anion-exchange flowsheet for recovering plutonium from oxalate supernates was reported in the June monthly progress report (HW-74153 C). An extended test has now been completed which confirms that the nitric acid stability of the recommended resin (Permutit SK) is more than adequate for this application. Hot (58 C) 10 M nitric acid was circulated continuously for seven weeks through a bed of 30 to 50 mesh resin (converted to the nitrate cycle with 0.6 M HNO_3 to minimize bead cracking). Following this prolonged exposure, the plutonium capacity of the resin was measured under carefully standardized conditions and found to be 64 grams per liter, only slightly lower than the maximum observed capacity of fresh resin (72 to 75 grams of plutonium per liter). There was no observable damage in the resin except an amber to orange color change of some 10-20 percent of the beads. This experiment clearly indicates that, in a plant RMC line application, the resin life will be limited by factors associated with alpha radiolysis and nitrite attack. These factors would be no more detrimental in 10 M nitric acid than in 7 M, for which there are many years of plant experience.

Recovery of Pu and Np from Purex Plant 1WW

Plutonium in Purex plant 1WW is in the tetravalent state while neptunium present is largely Np(V) . When 1WW was made 0.02 M in hydrazine and allowed to stand for 30 minutes at room temperature, Np(V) was reduced to Np(IV) . On contact of this solution with an equal volume of 0.04 M D2EHPA - 0.02 M TBP - Soltrol, 98 percent of the plutonium and over 99 percent of the neptunium were extracted. At an aqueous-to-organic ratio of five, about 90 percent of the plutonium and neptunium were extracted. Loading of the solvent with inert zirconium is thought to account for the reduced extraction of plutonium and neptunium at the higher l/v . The principal contaminants in the extracted plutonium and neptunium were Zr-Nb-95 and iron; some americium was present. Zirconium-niobium decontamination factor was ca. four at an l/v of one, and eight at an l/v of five. Addition of EDTA to the 1WW before extraction improved zirconium decontamination only slightly. Over 97 percent of the neptunium and plutonium and most of the Zr-Nb-95 and iron present were stripped on contact of the organic with an equal

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volume of 0.25 M oxalic acid. Contact of the stripped organic with an equal volume of 2.8 M NaOH removed the remaining Np, Pu, Zr-Nb-95 and iron.

Recovery of Sr-90 and Rare Earths from Purex FTW

Batch contact and mini-mixer-settler runs were made to test certain portions of a solvent extraction flowsheet for removal of Sr-90 and rare earths from Purex FTW waste. Feed for extraction column studies was 1965 FTW made 0.19 M in citric acid and adjusted to pH 4.3. Distribution of iron(III), Cerium(III) and strontium into D2EHPA - TBP - Soltrol solvent changed only slightly as the feed solution was allowed to stand at room temperature for periods up to 24 hours before extraction contacts. Chromium(III) and europium extraction decreased markedly with time before extraction indicating slower complexing of these elements with citrate. For the extraction of rare earths, operation of the extraction column at 60 C instead of 25 C appears advantageous due to the relatively slow attainment of equilibrium extraction by the rare earths at 25 C. For a three-minute contact time (estimated as approximate residence time in a plant scale column) K_d 's for cerium and europium at 60 C were 22 and 65 times those at 25 C, respectively. Distribution values for iron, chromium and strontium at 60 C were only four times higher, not significantly changed, and about two-fold lower, respectively.

In mixer-settler runs simulating the C Column (rare earth stripping), 99, 94 and 1.5 percent of the cerium, europium and iron present were removed with 2.0 M HNO_3 as the strip solution at an L/V of ca. 0.1. The behavior of cerium in A, B and C columns (extraction, partition and stripping) was not affected by eliminating TBP from the organic. Preliminary data indicate that 0.5 M oxalic acid is a satisfactory wash for C Column organic to remove residual iron and recondition the solvent for re-use in an A column.

Pulse Column Performance - DPA-NB System

The use of dipicrylamine (DPA) dissolved in nitrobenzene (NB) to extract cesium from a synthetic Purex waste supernate solution was successfully demonstrated in a nine-foot-high, three-inch-diameter pulse column. Cesium waste losses as low as 0.8 percent were obtained with 0.02 M DPA, yielding HTU's in the range of 1.6 to 1.9 feet. Volume velocities as high as 630 gph/ft² (sum of phases) were obtained, though the above optimum efficiency was observed only at rates on the order of 480 gph/ft² or less.

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The cesium was readily stripped from the solvent with 0.5 M HNO_3 . Waste losses of 0.6 percent or less ($\text{HTU} = 1.6 \text{ ft}$) were obtained in the nine-foot column at volume velocities of 370 and 780 gph/ft^2 . Scrubbing studies were also made, using 0.25 M citric acid to remove extracted sodium from the solvent. Tentative results indicate that sodium decontamination factors of 100 or more are readily obtainable with a cesium loss (or reflux) of less than 2 percent. The capacity of the scrub column was comparable to the stripping column.

Pulse Column Performance - D2EHPA System

Volume velocities as high as 700 gph/ft^2 seem to be assured in the 1A column when processing solids-containing feeds. Either zirconium phosphate or sodium silicate added to the feed to simulate the solids that might be present in FTW (1965 Purex waste) lowered the maximum stable frequency by about 10 to 20 percent. This relatively minor loss in stability could readily be recovered by adding about 50 ppm of a talc to the feed and scrub streams. Clinoptilolite fines added to the feed had no discernible adverse effect.

The inability to quantitatively scrub cerium from the solvent, as described last month, still has not been resolved; however, several successive passes of the solvent through the column eventually reduced the cerium content to about 1 percent of the feed. Addition of 0.2 M oxalate or hydrogen peroxide to the 2 M HNO_3 scrub seemed to have little effect on cerium stripping.

Cesium Recovery with Clinoptilolite

In pilot plant studies in support of the clinoptilolite process for recovering cesium, a simulated "A" farm supernate diluted with an equal volume of water was pumped downflow at room temperature through clinoptilolite in a 46-inch-long by 4-inch-diameter plexiglass column at 45 gph/ft^2 . This feed was $5 \times 10^{-4} \text{ M}$ in cesium and was traced with cesium-134. A fine solid, the nature of which is not yet clear, remained suspended in the water solution even after dilution of the simulated supernate to form the experimental feed. As a result the pressure drop in the upper part of the bed reached a maximum of about 0.2 psi per foot, whereas the maximum drop in the lower part of the bed was 0.1 psi per foot. The solids retained in the bed were readily removed by the upflow water wash in preparation for elution. The absorption cycle was characterized by an almost constant minimum cesium loss of about 1.5 percent. Five percent breakthrough occurred at about 17 bed volumes and 50 percent breakthrough was reached after about 30 bed volumes.

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Elution of the cesium (more than 95 percent) was done in less than 11 bed volumes with a combination of 1 N ammonia and 3 N ammonium carbonate at 55 C and pumped upflow at about 90 gph/ft². The aqueous ammonia was added to suppress gassing. The maximum cesium removal occurred after a throughput of two bed volumes.

A water-nitric acid pretreatment of the clinoptilolite as received reduced its volume by about 20 percent, owing mainly to dissolution of the occluded material. Loading and unloading the column proceeded smoothly. The mineral in water was readily transported to the column from a blow case with 20 psig air pressure. It was readily removed from the column by water fluidization.

Product Forms

Improved estimates were made of thermal conditions in containers of zeolite loaded with Cs-137. The estimates take into account the amount of gamma decay energy that escapes the container without contributing heat. Centerline and surface temperatures were calculated for containers of 8-, 10-, 12-, 16-, and 20-inch diameters, at cesium loadings of one, two and three milliequivalents per gram of zeolite. Typical results show that correction for gamma leakage in a container loaded to two milliequivalents cesium per gram permits increasing the diameter from 10.3 to 12.25 inches with no increase in centerline temperature. The complete study will be issued as document HW-74712.

Several types of solder were tested as possible bonding agents for the synthetic zeolites currently considered as final product forms for cesium and strontium. None was found which would wet the zeolites even with vigorous mixing when the solder was molten. Further exploration of the formation of glassy solids by fusion of the zeolites with a flux containing SiO₂, B₂O₃ and LiF was done. Several compositions were found which contained 30 weight percent of the zeolite and which formed true melts at or below 800 C and glass-like solids on cooling.

Remote Welding

Pressure tests were run on four, 5-inch-diameter, closure weld samples with the following results:

1. The weld ruptured at 3000 psi at room temperature
2. The weld failed after a hundred cycles from 0 to 2000 psi at room temperature

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3. The weld failed at 2000 psi at 300 C
4. Of the three container samples that were made with a V groove weld joint at one end and a raised flush face weld joint on the other end, all the samples failed in the raised flush face joint.

EQUIPMENT AND MATERIALS

Purex Concentrator De-Entrainment

Demonstration of the effectiveness of Purex sectionalized concentrator chevron baffles for de-entrainment of large liquid drops from a gas stream has been completed in a scaled-down baffle compartment. At a gas velocity of 35 ft/sec through the slots (15 percent greater velocity than expected in plant use) the actual entrainment that passed the baffles was 0.15 ml of liquid per 1000 cu.ft. of gas. Thus, mist loading of the final de-entrainment wire mesh separator should not be excessive.

Corrosion in 224-U Building Off-Gas Scrubber

A failed scrubber which treated off-gas from the 224-U Building continuous scrubbers was examined. Failure occurred in the area above the water inlet. Uniform intergranular corrosion attack had occurred. Huey tests on portions of the base metal indicated the scrubber was constructed of corrosion-passed 304-L material. No explanation for the apparent severity of attack, ca. 5 mils/mo, is yet evident. Replacement units were fabricated from heavier gage material.

Stress Cracking of Mild Steel

The large (3 ft. x 3 ft. x 3/8 in.) welded test plates described last month were removed from the test solutions for examination after about three weeks' exposure. No cracking was evident in any of the samples. They were returned for further exposure. Additional welded test specimens (10 x 12 x 3/8 in.) are being prepared from plate that has been cold worked by rolling on an 18-inch diameter.

PROCESS CONTROL DEVELOPMENT

Blending Control System

A control problem requiring accurate blending of a concentrated acid stream with oxalate supernate in a 234-5 Building plutonium

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recovery process was solved with an automatic ratio control system. The use of ratio control is required because the supernate flow-rate is dependent on a tank weight factor control and hence is an uncontrolled variable. An instrumentation system was devised, demonstrated in the laboratory, and sent to the Chemical Processing Department for installation in the plant. The system is comprised of a rotameter with a flow recorder-transmitter, another rotameter with a ratio controller, and a manual-remote set point station. The rotameter-flow recorder-transmitter provides a signal proportional to the supernate flow rate. This signal, in combination with a mechanically-set ratio, determines the set point of the ratio controller which controls the acid flow.

Neutron Monitoring Instrumentation

The gradient control system for the new Plutonium Reclamation Facility requires a directionally sensitive neutron monitor to detect small changes in plutonium concentration in a column, when a nearby column contains a higher concentration of plutonium. A shield consisting of six inches of paraffin and 20 mils of cadmium was found to reduce neutrons from a Pu-Be source by a factor of ten. A mock-up of the PRF columns has been set up to determine the actual count rates from plutonium solutions in the columns. Laboratory tests were also performed on transistorized neutron counting instruments. The equipment performed satisfactorily during the short-term tests. Higher reliability of transistorized instruments, as compared with vacuum tube instruments, is expected but the present tests were of insufficient duration to confirm this advantage. Some difficulties with noise pick-up were experienced, but this problem was overcome by locating the charge-sensitive pre-amp close to the detector (within two or three feet). Present plans are to incorporate these solid state devices into the Gradient Control System for the PRF.

Boiling Point Monitor

A boiling point measuring device for the Redox dissolver underwent extensive laboratory testing using water and salt solutions. Repeatability of the instrumentation system is now within 0.15 C; however, discrepancies as high as 0.7 C have been noted between measured and calculated boiling points of salt solutions of various concentrations. Investigation is underway to determine the cause of the discrepancy, which may be due to a superheating effect or to a change in thermohm response. In the proposed plant installation, it is expected that a calibration method can be worked out to reduce the error to an acceptable level; the objective is to measure boiling points within an error of 0.5 C or less.

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C-Column Test Facility

In recent runs it was observed that the inherent statistical fluctuations in the column flowrates and LCX acid concentration influence the uranium profile in the column. For this reason, a new experimental procedure has been devised: The column is brought to a "steady state" condition and maintained there for about two hours. For three additional hours, the data logger is operated at maximum speed (0.8 minutes per scan) with the mid-column photometer in the LCU line and the split beam instrument in the LCW line. In addition, periodic samples are taken of the LCW and LCU for absorptiometer analysis. The mid-column profile is then determined as has been done previously.

The large amount of data collected during the second period will give very good estimates of the overall column performance, column stability, and the correlation existing between the stream variables, in addition to the profile data.

REACTOR DEVELOPMENT - O4 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Precipitation Techniques for Plutonium Isolation - Prototype equipment has been assembled for the study of the handling of simulated PuO_2 precipitates in a fused salt medium. Since PuO_2 settles immediately upon formation, means have been provided for the removal of the precipitate from the bottom of the precipitation vessel. The vessel has an open quartz tube extending through the bottom of the induction furnace into a separately controlled heating zone thus producing a freeze valve, sealing the bottom of the vessel. Melting the salt plug in the tube allows the molten salt to pass through a quartz frit filter for precipitate isolation.

Two tests of the freeze valve have been completed. The first test was successful in that the frozen plug was established and melted, draining the pot. The second test resulted in breakage of the quartz tube during melting of the frozen plug. Hopefully, breakage can be prevented by adjusting procedures, i.e., using relatively dry salt and maintaining the freeze zone at an elevated temperature of about 300 C.

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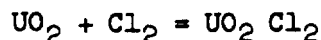
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Effect of Impurities on UO_2 Quality - A series of salt cycle UO_2 deposition runs is in progress to determine the effect of corrosion and fission products on the UO_2 deposited. Salt solution used was 60 w/o KCl - 40 w/o LiCl. All runs were of about 200 hours' duration; initial and final UO_2 content of the melt was about 25 and 10 percent, respectively. The UO_2 was deposited at a potential of about 0.6 volts vs. an Ag/AgCl electrode. The effect of one weight percent iron impurity was to decrease current efficiency and UO_2 crystal size. Product UO_2 contained about 100 ppm iron, had an O/U ratio of 2.004 and had a density near theoretical for UO_2 . No adverse effect was noted when the melt contained one weight percent of nickel or 0.42 weight percent of samarium. With 0.2 weight percent aluminum in the melt, UO_2 density was only 88 percent of theoretical. Cell resistance was increased three-fold but current efficiency was reduced by only about 10 percent. Current runs are being made with melts contaminated with zirconium and niobium. Preliminary observations indicate dissolution of UO_3 in these melts is difficult.

Electrochemistry of Uranium in Molten Chloride Salt Solutions - EMF measurements for the cell reaction



have been made in the LiCl-NaCl system, as a function of temperature and uranyl(VI) concentration. Thermodynamic values for the reaction at 943 K were calculated, the results showing the same trends as were found for this reaction in the KCl-NaCl system at 993 K (see monthly progress report for April, HW-73514 C). For a concentration increase from 0.035 to 0.725 molal uranyl(VI), the free energy change (ΔF , kcal/mole) for the reaction was found to increase from -25.3 to -18.6; the entropy change (ΔS , entropy units) increased from 3.2 to 9.8; and the heat of reaction (ΔH , kcal/mole) changed from -22.2 to -9.3. Comparing these values with those for the KCl-NaCl melt, it is seen that the free energy change for the reaction is more positive and, therefore, the activity coefficient for UO_2Cl_2 is larger, in the LiCl-NaCl system. The data as a whole indicate less complexing of the UO_2Cl_2 by chloride ion, because of lower chloride activity, in LiCl-NaCl than in the KCl-NaCl melt.

Fission Product Release During Salt Cycle Reprocessing - An initial test in a series of UO_2 oxidation measurements was made. The purpose of the tests is to establish reaction time for future fission product release studies related to the salt cycle reprocessing of PRTR fuel elements. Oxidation of a 1/2-inch diameter by 3/4-inch long UO_2 sintered, unclad cylinder was complete within two hours. The test was performed at about 570 C in an air atmosphere.

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RADIOACTIVE RESIDUE FIXATION

A-Cell Calciner Program

Installation of the calciners and associated equipment in A-Cell of the High Level Radiochemistry Facility was completed during the month and shake down runs are in progress. Both a pot-calciner run and a spray-calciner run (the latter with continuous melt down) with a synthetic feed were performed successfully, all operations being done remotely with the manipulators. A few minor piping leaks and other equipment deficiencies which were disclosed by these runs have been corrected, and tracer-level runs (with a spike of actual LW) will follow immediately to test efficiency of the off-gas system, samplers and analytical methods. The first full-level spray calcination run will then be performed, probably during September.

Analyses of the LW which was obtained for the program shows it to be relatively dilute (92 gal/ton). Ionic composition is: 0.29 M Fe^{+++} , 0.24 M $\text{SO}_4^{=}$, 2.4 M H^+ , 4.27 M NO_3^- , 1.3 M Na^+ , and 0.11 M Al^{+++} . Specific gravity is about 1.20. The high sodium content puts it in the non-melting area on the Shefcik diagram and will require the addition of about 0.64 moles of sulfate per liter to assure a fluid melt. Leaching and dissolution studies on the solids associated with the LW (cf. July monthly progress report, HW-74522 C) showed them to contain a large fraction (one-third) of the zirconium-niobium but relatively little of the other fission products or transuranics. However, strontium was more firmly held by the precipitate than was yttrium, promethium or cerium, about six percent being associated with the solids and not removed by a simple water wash, an observation which may have adverse implications for the Hanford Waste Management Program.

Since a question had been raised concerning the possible foaming characteristics of the plant waste and the effects these might have on operation of the pot calciner, several experiments were performed in B Cell with the actual LW which will be used as feed. Liter volumes of LW were boiled on a hot plate and evaporated to varying degrees. No foaming was observed, even when evaporation was carried almost to dryness (ten-fold volume reduction). On the basis of these observations, no foaming problem is expected in the calciner.

As part of a pre-startup hazards study, the concentrations of iodine-131 which might be released to the 325 Building stack by mal-operation of the calciners was calculated. Due to the age

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of the 1WW (≥ 200 days), the amount present in any run (most pessimistic basis) is less than one millicurie (probably much less). Concentration in the stack gas would range from 10^{-3} to 10^{-9} of MPC and be undetectable.

Synthetic Zeolites

Determination of equilibrium constants for the synthetic zeolites Linde 4AXW, Linde 13X, Linde AW-300, Linde AW-400, Linde AW-500, Zeolon and clinoptilolite continued. Systems for which the equilibrium relationships were determined with the above zeolites included rubidium-cesium and hydrogen-strontium. This completes the study of the effect on strontium or cesium loading of another alkali metal, alkaline earth metal, hydrogen or ammonium ion.

BIOLOGY AND MEDICINE - 06 PROGRAM

TERRESTRIAL ECOLOGY - EARTH SCIENCES

Hydrology and Geology

Adaptation of the computer program for fitting multiple-dimensional equations to tabular data is essentially completed. The program has surface fitting application in describing the basalt configuration beneath the project and in obtaining an analytical expression for the ground water potential over the project with measurements made in the irregularly-spaced wells. These data are essential for the permeability determinations needed for construction of the ground water electrical analog.

Methodology was studied for the ground water analog model and associated input and readout systems. Techniques and equipment were tentatively selected. The proposed system, which will consist of resistor networks mounted on circuit boards, a ratio digital voltmeter for readout, and associated scanner and switch-gear, is being examined by Instrument Research and Development Operation personnel for optimization of design.

A number of wells were resurveyed to determine if their actual field positions were the same as those reported at the time the wells were drilled. The results show that three wells drilled prior to 1950 were off about 100 feet and one was off 800 feet from previously reported positions. Wells drilled after 1950 were off from 20 to 50 feet. For the construction of the ground water analog model, it is desirable to know the location of project wells to within 100 feet of their true location. It

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appears necessary, therefore, to resurvey a number of other wells (maximum of 16) drilled during the period 1947-1950.

Three samples of volcanic ash received from the Oregon State Bureau of Mines were reported to contain 95 - 97 percent clinoptilolite. X-ray diffraction patterns of this ash indicate that it is higher in clinoptilolite content than that obtained from Nevada but not as high as the samples from Hector, California. The cesium exchange capacity of the samples is being determined.

Two wells completed by the Haden Drilling Company, one north of the 300 Area and one south of it, encountered artesian water immediately above the basalt in a sand and gravel bed. The artesian heads, compared to those in three similar wells recently completed in Richland and West Richland, and nine older wells in the vicinity, clearly indicate a southeastward gradient in that aquifer. The possibility that the source of recharge may be the 200 East Area ground water mound is being evaluated through the use of geologic and ground water temperature data.

ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Environmental Studies

Preliminary measurements of plutonium in lung and lymph node tissues have been completed for steers from the Riverview, Kahlotus and Wapato areas. The results indicate that Columbia River water is probably not a significant plutonium source insofar as insoluble plutonium species contribute to the radiation dose received for all sources by Riverview cattle. For lung tissues the plutonium concentrations were generally $\leq 1 \times 10^{-3}$ DPM per gram of Riverview bronchial nodes, $8 \pm 6 \times 10^{-3}$ DPM per gram of Riverview mediastinal nodes, $9 \pm 7 \times 10^{-3}$ DPM per gram of Wapato bronchial nodes, and $< 1 \times 10^{-3}$ DPM per gram of Wapato and Kahlotus mediastinal nodes. These concentrations are comparable to those for fallout plutonium reported from the HASP studies, and represent less than about 0.25 percent of the MPC for ingestion of these tissues by the general population.

Fallout Studies

Measurements of a sample of caribou meat from Alaska indicate a Cs-134/Cs-137 ratio of about 0.01. Allowing for radioactive decay, this is comparable to the ratio of 0.016 determined by Swedish investigators for reindeer meat in March, 1961. The low fission yield of Cs-134 ($< 1.4 \times 10^{-5}\%$) and seemingly wide distribution of

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this isotope (from Sweden to Alaska) suggest that the origin of Cs-134 in fallout is not explained simply by the Windscale accident, as has been postulated by others.

Columbia River Sediments

A sediment sample taken from the McNary Dam reservoir on 5/16/62 has been fractionated by sieving and sedimentation techniques, and the distributions of Co-60, Sc-46, Zn-65 and Zr-95 have been determined for the various fractions. Generally, specific activities of these isotopes increased with decreasing particle size in the fractions, but the increase is not linearly related to the increase in surface area of the particles. Co-60 behaves differently in that a higher specific activity is noted for the coarse fraction, decreasing and then increasing again with decreased particle size below 38 microns. This behavior is possibly related to the presence of organic material in the coarse fraction.

RADIOISOTOPES AS PARTICLES AND VOLATILES

Particle Deposition in Conduits

A computer program was written to calculate tube wall deposition for a distribution of particle sizes passing through a vertical conduit. The versatility of the program permitted rapid and accurate comparisons of experimental data with theoretical equations and derived empirical relations. A correction was introduced for velocity change with position in the tube due to pressure differences which had not previously been taken into account. Applied to a 1/2-inch diameter tube, 60 feet long, and with the previously developed correlation function, the computer program predicted total deposition of from 85 to 120 percent of that determined experimentally. With the turbulence theory equations of Friedlander and Johnstone¹ the computation predicted a deposition of from 100 to 113 percent of that measured. Although experimental errors could account for either positive or negative discrepancies of the magnitude indicated, it is worthwhile noting that a prediction greater than 100 percent should be expected with the turbulence theory. This is so because the inertia term, $d^2\rho$ (d = diameter, ρ = density of the particle), for actual particles is generally less than for

1 Friedlander, S.K. and H.F. Johnstone, "Deposition of Suspended Particles from Turbulent Gas Streams", Ind. Eng. Chem. 49: Pt. 2, 1151. July 1957.

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the assumed spherical particles. A lower inertia term would tend to decrease the magnitude of the predicted deposition. The computer program will be of considerable value in planning and evaluating forthcoming deposition experiments.

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Manager
Chemical Research and Development

WH Reas:cf

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BIOLOGY OPERATION

A. ORGANIZATION AND PERSONNEL

Dr. F. P. Hungate returned from a one-year leave of absence to assume the position of Manager, Plant Nutrition and Microbiology.

GENERAL

During the month five scientists from Biology attended the Second International Congress for Radiation Research in Harrogate, England, where four of them presented papers. The Congress was well attended by representatives of most nations and laboratories. Although our contingent felt the trip of great value, no outstanding contribution to understanding radiation effects was apparent.

Six young blond miniature swine were sent to Hammersmith Hospital in London, England, for use in studies on neutron radiation of skin.

Total fire loss, due to the July 29 fire in the plant growth chamber laboratory is now estimated to be \$27,000. Restoration of the room is \$4,900. Loss due to damaged equipment and materials is \$10,000. It is necessary to replace one climatizer unit completely. This unit initially cost \$2,000, however, the replacement cost will be about \$12,000. This increase in cost is due in part to advanced design and in part to rise in cost (labor and material). All loss values are based upon first cost figures.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - O2 PROGRAM

Effect of Reactor Effluent on Aquatic Organisms

After young chinook salmon were reared in effluent water for three months (April-June) the fish were tested for swimming performance in the hydraulic flume. The swimming tests are completed and a total of 58 groups with 11 fish per group were tested. Preliminary analysis of the data showed no statistical difference in performance times within similar size groups due to 3 or 5 per cent effluent. Regardless of treatment all groups showed an improvement with trials. The correlation coefficient between the first and second trial for eight groups each from 0, 3, and 5 per cent effluent was 0.608 (22 d.f.), which is significant at the 0.01 level.

The second monitoring test of 1962 was initiated at 100-K in August with young rainbow trout. The test is scheduled to be terminated in either October or November.

Columnaris

Miscellaneous small fish collected from sites on the Yakima, Beaver House, and 100-H slough were free of columnaris. Adult fish from Ringold and McNary were also negative. Columnaris was found on the gills of one adult squawfish from the Richland site.

Trout and salmon from troughs at 146-FR and 100-KE were positive for columnaris, 66 to 81 per cent of dead fish were infected.

BIOLOGY AND MEDICINE - O6 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Columbia River Limnology

Plankton counts of samples collected at Vantage and near Hanford were initiated. During mid-winter Asterionella and Tabellaria were the dominant diatoms, followed by Fragillaria, Synedra and Gomphonema.

Nitrates in the river nearly doubled since mid-July, sodium concentrations decreased and other elements measured remained fairly constant.

Phosphorus

The cichlids being maintained on a daily P^{32} diet since January 1962 started spawning in August. Spawns from three pairs of the low treatment group ($0.04 \mu\text{C/g}$ food) and one pair from the controls are under observation. Although the number of spawners are still few in number, among the spawners there is no indication of radiation damage. Estimates of the average concentration of P^{32} in the fish after seven months of isotope feeding are $0.052 \mu\text{C/g}$ fish, $0.15 \mu\text{C/g}$ fish, and $0.40 \mu\text{C/g}$ fish for low ($0.25 \mu\text{C/g}$ food), medium ($1.0 \mu\text{C/g}$ food), and high ($4.0 \mu\text{C/g}$ food) treatment groups, respectively.

Zinc

The distribution of Zn^{65} expressed per g of wet tissue in rainbow trout a week after a single oral administration of $9 \mu\text{C}$ showed the activity in organs or tissue in the following descending order of magnitude: gill filament, spleen, kidney, bone, liver, eye, blood and muscle. The relatively high activity in the gill filaments (52 nc/g) is attributed to the high carbonic anhydrase activity of this tissue. In contrast to the gills, the muscle was only 1.9 nc/g .

Strontium

Fe^{59} plasma clearance and erythrocyte uptake and Cr^{51} -tagged erythrocyte survival were determined in control and 25 and $125 \mu\text{C Sr}^{90}/\text{day}$ fed miniature swine. No apparent differences were observed in the Fe^{59} plasma clearance of the various animals. Fe^{59} uptake by erythrocytes was somewhat more rapid in 25 and $125 \mu\text{C Sr}^{90}/\text{day}$ animals than in controls, but did not reach as high levels. Most control animals reached maximum uptakes of ~80 per cent of the injected dose by seven days post-injection, at which time the Sr^{90} fed animals had values of ~70 per cent, which they had attained by five days post-injection. The survival time of Cr^{51} -tagged erythrocytes was significantly less in the $125 \mu\text{C Sr}^{90}/\text{day}$ animals than in the control or $25 \mu\text{C Sr}^{90}/\text{day}$ animals. At 16 days 70 to 80 per cent of the Cr^{51} -tagged erythrocytes still remained in the control and $25 \mu\text{C Sr}^{90}/\text{day}$ animals, whereas only 55 per cent remained in the $125 \mu\text{C Sr}^{90}/\text{day}$ animals. A marked reduction in the per cent of tagged cells remaining in the

125 $\mu\text{c}/\text{day}$ animals was noted in the first few days post-injection, perhaps indicating that a portion of the cells labeled had a very short survival time. (These studies will be repeated using additional animals at the 125 μc $\text{Sr}^{90}/\text{day}$ level.) These animals have a radiation dose rate to the bone of ~ 20 rads per day with bone marrow dose rates being slightly less.

Plasma iron determinations have been made on a number of animals for possible correlation with the radioiron studies. Considerable variation in values was observed between animals within a group and in the same animal on repeated determinations.

Platelet determinations were made on a large number of animals and it appears that animals on the 25 μc Sr^{90} per day level have values approximately two-thirds of the controls. A more marked reduction is evident in 125 μc per day animals.

Ruthenium

Plasma and milk concentrations of Ru^{106} were followed for ten days in three lactating ewes following a single intravenous dose of Ru^{106} nitrate. Peak concentrations were observed in the milk at 7 to 11 hours post-injection, at which time they were only about 1 per cent of the plasma concentration. Of ten radionuclides studied to date, Ru^{106} has shown the least affinity for movement from plasma to milk.

Iodine

An I^{131} feeding study was initiated in three dairy cows and three sheep. The study is designed to simulate a single contamination event on forage in that the animals are being fed I^{131} -labeled feed twice daily, each feed sample being spiked on day one with 5 μc per sample.

Peak thyroidal I^{131} concentrations in the three cows occurred after one week and remained fairly constant during the second week with about 55 per cent of the first day's dose (10 μc) detected in the thyroid. Peak milk concentrations occurred on the fourth day post-administration with about 0.4 per cent of the initial administered dose observed per liter of milk. Peak thyroid concentrations in the rams were observed after about eight days and approximated 200 per cent of the first day's dose.

Neptunium

Fatty infiltration of rat liver from the injection of as little as 6 mg/kg Np^{237} is so dramatic as to be grossly recognizable as early as six hours post-injection. Liver lipid content as a function of time is expressed in the following table:

Per Cent of Dry Liver Weight Composed of Lipids

<u>Hours after injection</u>	<u>Np Treated</u>	<u>Control</u>
0	10-15%	10-15%
24	24-32%	
48	45%	
72	54%	

This response is similar to that of certain lanthanides, but is not necessarily a heavy metal syndrome since it is not elicited in the same degree by Pb.

The lipids are being further fractionated to see which are responsible for the infiltration.

In cooperation with CR&D, samples of urine and sera from Np-injected animals have been spectrophotometrically analyzed. Very preliminary results suggest the existence of the IV state in urine, but this requires confirmation.

Plutonium

When injected intraperitoneally at a level of 1 $\mu\text{c}/\text{rat}$, Pu^{238} and Pu^{239} are similarly distributed within the animal. When injected at a level of 15 $\mu\text{c}/\text{rat}$, Pu^{239} is more concentrated than Pu^{238} in liver, spleen, and kidneys, and less concentrated than Pu^{238} in bone.

Since the metal precipitant, 8-hydroxyquinoline (8-OHQ), causes a short duration, diabetic condition in rats, it may have access to sites not visited by DTPA. However, its effectiveness in promoting Pu excretion was only a fifth that of DTPA and both agents used together were about 2/3 as effective as DTPA alone. However, the 8-OHQ did cause increased fecal excretion that was twice the control level even on the fifth day so that the idea of tying up the Pu as an insoluble material and elimination by phagocytosis or sequestration with a second agent should be tested further.

Plutonium and X-Ray

Plutonium-238 and Pu^{239} show equivalent acute toxicity when injected intraperitoneally at a level of 6.5 $\mu\text{c}/\text{rat}$, in animals also exposed to 500 r whole-body X-ray. An amount of Np^{237} equivalent in weight to the Pu^{239} dose ($\sim 100 \mu\text{g}/\text{rat}$) was not acutely toxic when administered in combination with 500 r whole-body X-ray. These two findings indicate quite conclusively that the acute toxicity of Pu^{239} when combined with 500 r whole-body X-ray is due to the alpha radiation damage and is not complicated by heavy metal toxicity.

Radioactive Particles

The effectiveness of DTPA on the removal of inhaled $\text{Ce}^{144}\text{O}_2$ in dogs was confirmed in additional studies. In untreated dogs the inhaled $\text{Ce}^{144}\text{-Pr}^{144}$ was retained with an effective half-life of 90 to 150 days, depending upon physical characteristics of the aerosol. The half-life for retention of $\text{Ce}^{144}\text{-Pr}^{144}$ was decreased to about 8 days when DTPA was administered immediately after exposure, to 10 days when treatments were started 5 days after exposure, to 30 days when treatments were started 9 days after exposure, and to 36 days when treatments were started two months after exposure. In all dogs being treated the effective half-life gradually increased, but excretion of $\text{Ce}^{144}\text{-Pr}^{144}$ three months after exposure continues to be more rapid in the treated animals than in the controls, with one exception. Treatment with DTPA immediately after exposure resulted in a rapid drop of the body burden of $\text{Ce}^{144}\text{-Pr}^{144}$ to less than 5 per cent of the amount initially deposited. This was the optimum time for treatment. However, further excretion is occurring at rates comparable to those observed in the untreated dogs. This suggests that we will never be successful in completely decontaminating an individual exposed to radioactive aerosols; that there will always be a residual fraction.

Lung biochemistry studies were initiated. The protein content of lung tissues is extremely low, about 1 per cent of that in liver.

Thirty months after exposure two dogs on the long-term $\text{Pu}^{239}\text{O}_2$ experiment are beginning to show increased respiratory rates, one of the earliest signs of respiratory damage. Another has a persistent cough and a slightly elevated respiratory rate.

Preliminary data were obtained on 6 dogs scheduled for exposure to aerosols produced from 1 curie of Ce^{144} for acute toxicity studies.

SPSS (sodium polystyrene sulfonate), obtained from Dr. Kroll (Eltex Laboratories), was tested as a therapy agent on rats exposed to $\text{Pu}^{239}\text{O}_2$ and to others exposed to Pu^{239} nitrate aerosols. It appears to have no effect on the clearance of inhaled Pu^{239} .

Three bitches in the breeding colony will whelp within the next month. A temporary halt in our breeding program has been initiated because of insufficient kennel facilities. This will cause a shortage of experimental animals during fiscal year 1964. The use of sawdust in the dog runs has been discontinued because of the dust and the high probability of bringing in parasites and infectious agents. As a result the runs will be more offensive to Biology personnel and visitors but we hope to overcome this with use of deodorants, Pinatol and V-tergen. The dog colony presently consists of 71 dogs on experiment, 8 available for experiment, 45 puppies, and 21 dogs in the breeding colony - a total of 145 dogs.

Modification of Secondary Disease

Some progress has been made in developing analytical procedures to test for circulating antibodies. After three injections of mouse RBC to rats, the anti-mouse titers reached a maximum of 10^{-5} in three weeks after the last injection and declined to 10^{-2} by the sixth week. The rat anti-sera is not too specific since rats primed with LAF RBC's agglutinate C3H RBC's at comparable dilution titers. Mice were not as sensitive to rat antigens, showing a maximum titer of 10^{-3} .

Cellular Studies

Cichlid eggs were exposed to from 50 r to 1,000 r X-rays in a series of tests to determine survival. A dose of 500 r resulted in only a 30 per cent hatch. Dosages above 500 r were 100 per cent lethal to the eggs within five days. The LD₅₀ as determined by the ability of the eggs to hatch is approximately 475 r.

Young cichlids (three days after hatch) were exposed to from 500 r to 20 kr X-ray in a series of tests to determine survival of the fish. Dosages of 3 kr and higher were 100 per cent lethal within 7 days. A LD₅₀ - 7 days of approximately 2.25 kr was observed. Hyperactivity of the three-day old cichlids was observed following X-irradiation of the fish. An avoidance response occurred when fish were externally exposed to Cs137. It appears that the fish were avoiding the radiation. Control fish reacted normally. It is not known whether the fish were actually reacting to the radiation or to possible chemical changes produced in the water during irradiation. Fish placed immediately into X-irradiated water showed no apparent effect.

Previously we have shown that D₂O strongly inhibits respiration and glycolysis. Data indicate that these effects are linked with D₂O inhibition of glucose and phosphate uptake. These studies have now been extended to fully deuterated glucose in both D₂O and H₂O systems with the following results. In H₂O uptake of deuterated glucose is only slightly less than controls (ordinary glucose in H₂O), and uptake of phosphate is unaffected. In D₂O uptake of deuterioglucose and phosphate are inhibited to the same extent as when ordinary glucose in D₂O was used. Respiration (O₂ uptake) is, however inhibited 10 per cent in H₂O and 50 per cent in D₂O by deuterioglucose. The latter inhibition is similar to that seen with ordinary glucose in D₂O. It appears then, that uptake effects are a major cause of respiration inhibition.

Plant Studies

Increasing levels of fertilizer potassium did not increase K contents of plants grown in the Cs-K plots. Leaf contents were approximately half of the stem values. No differences were found with respect to method of fertilizer application, i.e., surface or mixed treatments. Leaf/stem ratios

for K were constant throughout treatment whereas the ratios for Cs decreased with increasing levels of K applications. The immediate inference is that K treatments reduced translocation, however, this seems unlikely in view of the K status of the plants.

Plant Ecology

Vegetational analyses conducted in sagebrush-cheatgrass communities one year after the area was burned by late summer prairie fire showed that the fire was deleterious to the subsequent stand of winter annuals such as Draba verna and Phlox gracilis. Perennial grasses (Poa secunda) were little affected and the growth of Russian thistle was favored by the burn.

Mineral Cycling in Ecosystems

Cesium-134 uptake from pond water by duckweed (Lemna) was rapid during the first day. During two weeks after the first few days of Cs¹³⁷ accumulation, the uptake appeared to decrease with time.

Project Chariot

More than 183 samples of plants, fish, birds and mammals were collected near Cape Thompson, Alaska, and shipped to the Hanford Laboratories for radio-chemical analyses.

Whole-body counting of Alaskan Eskimos for fallout radionuclides was completed. The Cs¹³⁷ body burdens in natives from different ecological areas were as follow:

	No. of people measured	nc Cs ¹³⁷	
		Average	Maximum
Little Diomed Island	17	27	55
Point Hope	102	17	120
Barrow	256	52	170
River People (Villages along Kobuk and Noatak River drainages)	49	140	310
Kotzebue	150	140	520
Anaktuvuk	53	420	790

The low levels for the Point Hope and Diomete Island people are attributable to their extensive usage of marine animals which are low in fallout radio-nuclides and to lack of caribou to the Point Hope natives during the summer. The highest levels of Cs¹³⁷ occurred among people who depended most upon

freshwater and terrestrial organisms for food, caribou and reindeer being the main source of the radionuclide. Eskimo students who had recently returned from attending schools where native foods were not available contained much lower levels than natives who had permanently resided in their Arctic villages and hunting areas.


Manager
BIOLOGY OPERATION

HA Kornberg:es

C. Lectures

a. Papers Presented at Society Meetings and Symposiums

Second International Congress of Radiation Research, Harrogate, England, August 5-11, 1962:

L. K. Bustad and L. D. Carlson. Response of mice to prolonged low-dose gamma irradiation.

S. Marks and L. K. Bustad. Thyroid adenomas in sheep fed radioiodine.

R. O. McClellan, Glenda Vogt, J. R. McKenney, N. L. Dockum, W. J. Clarke, and L. K. Bustad. Effects of daily Sr^{90} ingestion in miniature swine.

M. F. Sullivan, S. Marks, and R. C. Thompson. Delayed effects in rats of chronic yttrium-90 ingestion.

H. E. Erdman. X-ray effects on single and mixed species populations of Tribolium confusum and Tribolium castaneum (Coleoptera: Tenebrionides).

1962 Fall Meeting of the American Society for Pharmacology and Experimental Therapeutics, Vanderbilt, University, Nashville, Tennessee, August 27-30, 1962:

E. G. Tombropoulos. Treatments for removal of inhaled $\text{Ce}^{144}\text{O}_2$ from the lungs of rats and dogs.

b. Off-Site and Local Seminars

L. K. Bustad. August 3, 1962. Large animal radiation biology at Hanford. Agricultural Research Council Radiobiological Laboratory, Letcombe Regis, England.

Hanford Seminar for Science Teachers, August 30, 1962, Richland.

J. E. Ballou. Small animal studies with internal emitters.

D. D. Mahlum. Study of radiation at the cellular level.

R. C. Thompson. Brief history of radiation biology and trends of research at Hanford.

J. F. Park. Radioactive aerosol studies.

W. H. Rickard, Jr. Fallout in relation to natural landscapes.

University of Washington Summer Institute in Radiation Biology, August 6-7, 1962, Richland:

E. G. Tombropoulos. Problems of particle inhalation.

R. T. O'Brien. Radiation effects on cell permeability.

W. J. Clarke. Biological effects of I^{131} .

N. L. Dockum. Autoradiography.

1962 AEC Health Physics Fellowship Program, August 13, 1962, Richland:

W. J. Bair. Inhalation problems.

c. Seminars (Biology)

None

d. Miscellaneous

None

D. Publications

a. Documents (HW)

None

b. Open Literature

Mc Kenney, J. R., R. O. McClellan, and L. K. Bustad. 1962. Early uptake and dosimetry of Zn^{65} in sheep. Health Physics 8, 411.

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HW-74-3

APPLIED MATHEMATICS OPERATION
MONTHLY REPORT - AUGUST, 1962

ORGANIZATION AND PERSONNEL

Effective August 1, 1962, the name of the group was changed from Operations Research and Synthesis Operation to Applied Mathematics Operation.

OPERATIONS RESEARCH ACTIVITIES

The study of the Tri-City economic structure is gathering momentum. Special Census Bureau data have arrived and are being tabulated. Preliminary studies are being made of HAPO records. The definitional phase of the work should be completed by the end of September.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Meetings were held to discuss methods of modifying the present linear programming model of the FPD Production Forecasting Process. Alternative methods were devised which should allow the model considerably more freedom in balancing safe inventory levels, idle time, and added capacity requirements.

Further nondestructive testing was performed on the uncharged fuel elements from multiple failure lot HZ-065, and on fuel elements sampled from eight "control" lots. The purpose of this testing is to see if there are measured characteristics which could have differentiated between the quality of this lot and that of nonrupture lots. Great care is being taken to remove the effects of tester error in assessing the quality. Measurement data from the second complete set of measurements were analyzed during the month.

Total count data for dingot fuel elements canned under canning conditions somewhat different from those used for ingot material were compared with similar data for ingots. In view of large between-line differences existing for the ingot fuel elements, only gross differences between ingot and dingot fuel elements could have been detected.

Assistance was provided in the preparation of certain fuels statistics for use in a forthcoming Metal Quality Working Committee Report. This consisted primarily in quantifying effects of "time" on total bond count, warp, and rupture experience.

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Data from two similarly conducted fuel element pilot plant tests were analyzed. In one test, spire-can components were utilized, while in the second test, the components were double cleaned. In each instance, the effects of canning cycles and canning bath temperature on fuel quality, as measured by the UE-1 and UT-4 testers, were evaluated.

Additional data were collected to determine the effects of using different core and sleeve combinations on ellipticity of the canned fuel element. Results were very consistent with previous tests, as was stressed in the report.

The study concerned with evaluating the effects of certain process variables on some nineteen yield variables was completed. This was conducted primarily in order to assess the effectiveness of certain of these yield variables in detecting differences in fuel quality.

In connection with the straightening of warped NPR fuels, submitted data were analyzed to determine what amount of bending is necessary to effect a zero average warp on fuel elements after the second beta heat treating. This was impossible to determine because of the almost perfect correlation that existed in the data between the initial warp after beta heat treating and the warp after bending.

It is often necessary, when analyzing fuels data, to transform the data in some fashion in order to stabilize the variance and, incidentally, achieve normality. However, from an interpretation viewpoint, it is desirable to express results in terms of the raw data. A document has been prepared to permit this. For various transformations in which the mean and variance of the transformed variable are known, the corresponding means and variances of the raw data are given. In addition, the percent(s) of items exceeding some value(s) are also given. A series of graphs makes the results readily usable.

Irradiation Processing Department

The programs to perform the craft set analyses for reactor maintenance work have been completed and debugged. The second major program for translating work order numbers into either job codes or the classifications of facilities engineering, research and engineering, landlord, new work or project, has been completed and debugged. The master conversion table from work order numbers to job or class numbers is 99 percent complete. Time distribution records for the period June 3, 1962, through August 12, 1962, are now available and will be upgraded with the appropriate craft code shift assignment, crew assignment, and radiation status in preparation for the analytical passes describing craft effort involved in total maintenance function.

Considerable attention was directed towards the problem of assessing C-Basin Profilometer measurement errors. This work was occasioned by the large

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number of 80 and 90 profiles found to exist in recent analyses of bumper fuel element data. Several hundred fuel elements, both bumper and non-bumper, have been remeasured. Preliminary analyses indicate that there is nonuniformity in measurement error along a given fuel element. In addition, measurement errors in the two profiles are strongly correlated. All the data are currently being processed. Upon completing the analyses, recommendations will be made for processing future fuels data so as to minimize the effects of this measurement error. Changes in measurement techniques may also result from the study.

Work continued on the problem of estimating defect frequency and size distributions in connection with welded primary piping for the NPR Project.

Chemical Processing Department

The review of shipper-receiver differences for U-235 measurements was extended to include UO_3 produced from irradiated E metal.

The analysis of the data used to demonstrate dimensional stability of fabricated parts was completed.

An attempt is being made to estimate the efficiency of the plutonium processing operation for removal of specific impurities. Intermediate points in the process will be examined to aid in understanding process effects on the impurity content.

Work is continuing in connection with assessing risks associated with transporting fission products by rail.

Work continued on the refinement and programming of a mathematical model for spare parts and general inventory control.

Relations Operation

Work continues in planning for the forthcoming HAPC-wide attitude survey.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Pulse Column Facility

A FORTRAN language power spectral estimation program has been obtained from the UCLA Medical Center and is being used to analyze several pulse

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column equilibrium experiments. A number of variables which are recorded periodically during an equilibrium run of the column are being analyzed with this routine to establish the characteristics of the column under steady-state operation and to determine how these characteristics change as the column approaches a flooding situation.

A factorial experiment involving approximately 50 pulse column runs is being designed to study the extraction characteristics of the column as a function of six independent variables, extractant stream temperature, extractant stream acid concentration, feed stream acid concentration, feed stream and extractant stream flow rates, and the pulsing frequency.

3000 Program

Considerable time has been spent on checking out the response characteristics of the experimental Gorton Lathe to the EDPM-generated magnetic tape input. Data have been compiled on tape reading speeds, pulse-pattern accelerations and decelerations, and pulse counting.

Two EDPM programs have been completed and placed in service which serve to specify the design data for metal blanks which are to be shear-spun on a Floturn machine into preselected shapes. The program simultaneously specified lathe coordinates for cutting such blanks and lathe coordinates for cutting mold surfaces suitable for casting such blanks. The two programs differ in that one designs blanks which will be strained uniformly under shear spinning, whereas the other allows the coefficient of shear-strain to vary in a preselected manner.

4000 Program

An EDPM program is being written to analyze the frequency equation which predicts the modes of Lamb-wave propagation in metal plates. This piece of analysis is prerequisite to any satisfactory interpretation of experimental data.

5000 Program

Actinide Element Research

Several major problems in indexing hexagonal crystals have been solved. Work has progressed satisfactorily enough to warrant reconsideration of the orthorhombic case. Some work on the orthorhombic crystals was done about mid-August.

The problem of finding precise lattice constants of cubic crystals at various temperatures has been solved and the results turned over to the customer.

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A report describing the theory and application of the resulting program is being prepared.

A report (HW-74393) has been issued on the theory and application of a program to index cubic crystals. The program has been placed in the FORTRAN Library in 713 Building for plant-wide use.

Division of Research

Work continues on the definition of the IRA Mark II data filing system. The calculation parts of the system are the only sections not yet defined. The spectral resolution subroutine GEM for the calculation portion of the system is being checked out with a Monte Carlo program for generating the spectra.

Work continued on the modification of the ZERO FORTRAN language program to speed up its input-output characteristics. Routine machine plotting of program data using PICTURE continued to obtain gross characteristics.

6000 Program

Biology

Work continued on applying a multicompartiment model to a study of Pu retention in fish. Better approximations of rate parameters are being sought by using an iterative technique.

Work continued on data from an Alaskan fallout study. Presence or absence of isotopes is to be detected by analyzing data from a multichannel analysis.

Work was initiated on a statistical analysis of data to calibrate Alpha-Beta-Gamma Air Sample Counters.

Personnel Monitoring

The statistical analysis of data continued to evaluate the present pencil program. A computer program was written to perform the desired statistical calculations for the analysis.

Work is continuing on the problem of compositing urinalysis samples for the purpose of analysis. Frequency distributions of the disintegrations per minute are being compiled in order to determine how large the composite sample should be.

General

A statistical analysis was undertaken of mass spectrometer data on three gas standards. Approximately 50 independent analyses were run on each of

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the three standards. Data analysis will resolve the total variation into a between run component, individual peak components, and experimental error.

A nonlinear least squares analysis was performed on data from an experiment to investigate the kinetics of peroxide decomposition. Reaction rate, order parameters, and the initial composition of the peroxide were estimated and standard error calculations performed.

During the month, interviews were conducted with personnel interested in the information system study in Radio-Met. The conclusions drawn from these interviews indicated the key points of information required for operation and scheduling. Agreement was attained regarding the points presented, and the various supervisors were to coordinate specific definitions regarding their needs in order to permit the creation of a common language structure suitable for machine processing.

R. Y. Dean

Acting for
Manager
Applied Mathematics

RY Dean:dgl

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REACTOR DEVELOPMENT - 04 PROGRAMPLUTONIUM RECYCLE PROGRAMPhoenix Fuels Study

Fuel costs have been obtained for nineteen plutonium fuels of varying isotopic composition. The cases studied correspond to fuel rods from one-half-inch diameter to very fine rods approaching the homogeneous case. Medium and hard spectrum cases have been studied at three specific power levels. In addition, minimized fuel costs have been obtained for two of these fuels that showed Phoenix action. The fuel cycle costs have been minimized against spatial concentration of the fuel in grams fissile/cc.

The fuel costs shown in Table I are for arbitrarily compounded plutonium compositions to give an indication of the effect of Pu-240 concentration on fuel costs. Although these are not minimized fuel costs, in all cases studied to date minimum costs have been found to be with fuel concentrations close to the one gram/cc plutonium fuel density used for this table.

These results indicate that even though Phoenix action may occur, there is insufficient fertility for lowest fuel costs with many of the fuels with lower Pu-240 contents when the plutonium is used without benefit of other fertile substances such as U-238 or Th-232.

The specific power for all these cases (Tables I and II) is 300 MW/T (330 w/cc) which is equivalent to 30 MW/T at normal oxide density. Even lower fuel costs are obtained if the fuel is operated at a higher specific power level. Although reactors currently operate at about half this power density on the average, the peak powers incurred are comparable to this and fuel elements have been tested and operated at power densities in excess of this.

Successive Recycle of Bred Fuels

The calculation of the values of plutonium and U-233 in five simulated reactors for different fueling strategies is nearly complete. The scope of this study is shown by Table III. In this table, typical fuel values and fuel costs are presented for recycle of self-produced plutonium and U-233, and for plutonium recycle in natural uranium with an unlimited stockpile of plutonium. In all, six modes of operation with standard economic conditions are considered for each reactor type plus a number of additional cases designed to evaluate key nuclear and economic parameters.

TABLE I

FUEL COSTS (NOT MINIMIZED) FOR EIGHT PLUTONIUM FUELS
(1 gram/cc plutonium concentration)

Case No.	Plutonium Isotopic Percentage Composition (1 gram/cc plutonium concentration)				Fuel Cost mills/kwh
	Pu-239	Pu-240	Pu-241	Pu-242	
552	70	30	--	--	1.657
652	50	30	20	--	1.795
752	40	30	30	--	1.827
832	50	50	--	--	1.414
952	40	50	10	--	1.297
1052	30	50	20	--	1.345
1452	58	25	10	6	1.923

Economic Int. 12 percent, AEC Int. 4-3/4 percent, FEFJ \$0.61/cc (equivalent to \$30/pound at full oxide density), plutonium price 0.85 of top product (\$10.20/gram fissile).

Fuel costs used in the minimization for the two plutonium types that can be formed in reactors are shown in Table II.

TABLE II

MINIMIZED FUEL COSTS FOR TWO PLUTONIUM FUELS

Case No.	Plutonium Isotopic Percentage Composition (atom percent)				Fuel Cost* mills/kwh
	Pu-239	Pu-240	Pu-241	Pu-242	
1552	37	45	15	3	1.432
1952	45	40	10	5	1.538

* Economic rules same as Table I.

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TABLE III

COMPUTED RESULTS FOR SUCCESSIVE RECYCLE OF BRED FUEL

Listing Bred Fuel Values in \$/gram⁽¹⁾ (Missile) and Corresponding Fuel Costs in mills/kwh_e⁽²⁾
for Five Simulated Reactors and Six Operating Modes

Simulated Reactor Type	Plutonium Successively Recycled for Minimum Fuel Cost				U ²³³ Successively Recycled for Minimum Fuel Cost			
	Self-Produced Pu Recycled with Optimum U ²³⁵ Enrichment of U ²³⁸		Optimum Pu Quantity Recycled in Natural Uranium		Self-Produced U ²³³ Recycled with Optimum U ²³⁵ Enrichment of Th			
	Batch Loading	Graded Loading	Batch Loading	Graded Loading	Batch Loading	Graded Loading	Batch Loading	Graded Loading
APWR	12.10 (2.15)	11.80 (1.73)	11.10 (2.16)	(Not to be Calculated)	13.90 (2.63)	(Not to be Calculated)		
BWR	11.90 (1.74)	10.20 (1.28)	10.30 (1.77)	(Incomplete)	14.00 (2.00)	(Incomplete)		
HWR	11.50 (1.71)	10.30 (1.15)	10.20 (1.72)	(Incomplete)	14.00 (1.89)	14.20 (1.57)		F 1.3
GCR	12.70 (1.82)	11.80 (1.20)	11.20 (1.98)	11.20 (1.20)	13.60 (2.35)	13.40 (1.79)		
OMR	12.50 (1.96)	(Incomplete)	12.80 (1.75)	(Not to be Calculated)	13.10 (2.30)	(Not to be Calculated)		

Note: (1) Shown as the Top Figure for each Instance.

(2) Shown in Parenthesis for each Instance.

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As in the work reported in HW-72217, the optimum initial enrichment (for minimum fuel cost) constrained by the fueling strategy considered was used in the calculations. The present study differs in that:

1. The scope is much larger since only self-produced plutonium recycle was reported in HW-72217;
2. The price schedule established July 1, 1962, is used in the present study;
3. The MELEAGER burn-up code has been calibrated with the SPECTRUM multigroup diffusion code since the work reported in HW-72217 was completed.

The calibration of MELEAGER has generally increased the calculated plutonium values while not changing the values of U-233. This results from a revised epithermal cross section formulation which reduced the values of alpha in the present model to more correctly reflect the self-shielding in the resonances of Pu-239 and Pu-241. This formulation is still considered to be conservative and to yield plutonium values that are likely low, however.

Tables IV through IX show how the calculated values and the isotopic compositions vary with successive recycle. The reactors are listed in descending order of relative Pu-239 concentrations or relative U-233 concentration in the recycled fuel. Values are given for the first three irradiation steps or, as in Table IV, interpolated values for 15,000, 30,000, and 45,000 MWD/T of cumulative exposure.

Complete analysis of these results will take some time, although a few observations can be made. Plutonium values and fuel costs are generally higher for batch cycles than for graded cycles in the same reactor. Plutonium values are lower for the HWR than the other machines, especially for highly burned plutonium which has significant quantities of Pu-242. This latter effect appears to be due to the fact that the relative parasitic captures in Pu-242 are greater in the HWR because it has little other parasitic material present. It is observed that U-233 has higher values than plutonium but that the fuel costs are also greater. The higher fuel costs with U-233 are due largely to the necessity of starting the cycle and maintaining it with fully enriched U-235. This cost is more fully defrayed in reactors designed to more fully exploit the potential thermal breeding of U-233, and fuel costs may be reduced for such machines. This study does show that the value of U-233 is essentially the same for all reactors and for large accumulative exposures, which tends to support the fact that the properties of U-233 are relatively independent of the various thermal neutron spectra.

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TABLE IV
COMPUTED PLUTONIUM VALUES FOR BATCH IRRADIATION
IN FIVE SIMULATED REACTORS

Successive recycle of self-produced plutonium with uranium enrichments optimized for minimum fuel cost.
Uranium Price Schedule established July 1, 1962; 4.75 percent Use Charge Rate.

Cumulative Exposure of Recycled Fuel, MWD/T	Isotopic Composition of the Plutonium, w/o				Plutonium Value* in each Simulated Reactor, \$/gram fissile			
	239	240	241	242	APWR	OMR	BWR	HWR
15,000	67.4	21.3	9.2	2.1	12.10 (2.15)			
	67.0	19.0	11.0	3.0		12.50 (1.96)		
	62.3	22.5	11.2	4.0			11.90 (1.74)	
	61.5	24.9	9.3	4.3				11.50 (1.71)
	58.0	32.0	7.6	2.4				12.70 (1.82)
30,000	57.4	21.2	14.3	7.1		13.10 (1.96)		
	55.6	25.1	12.6	6.7	12.50 (2.15)			
	52.3	24.6	13.6	9.5			12.00 (1.74)	
	50.3	28.3	11.4	10.0				11.60 (1.71)
	44.9	37.5	9.5	8.1				13.10 (1.82)
45,000	52.5	21.2	15.2	11.1		13.30 (1.96)		
	50.1	25.5	13.5	10.9	12.40 (2.15)			
	47.8	24.4	13.9	13.9			11.60 (1.74)	
	45.0	28.3	12.0	14.7				11.50 (1.71)
	38.7	38.3	13.0	10.0				13.30 (1.82)

* The corresponding fuel costs are in parenthesis as mills/kwh.

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TABLE V
COMPUTED PLUTONIUM VALUES FOR GRADED IRRADIATION
IN FIVE SIMULATED REACTORS

Successive recycle of self-produced plutonium with uranium enrichments optimized for minimum fuel cost.
Uranium Price Schedule established July 1, 1962; 4.75 percent Use Charge Rate.

Step No.	Isotopic Compositions of the Plutonium, w/o				Cumulative Exposure of Recycled Fuel, MWD/T	Plutonium Value* in each Simulated Reactor, \$/gram (fissile)			
	239	240	241	242		APWR	BWR	HWR	GCR
1	56.2	24.6	13.2	6.0	22,220	11.80 (1.73)			
	52.0	26.3	13.2	8.5	22,925		10.20 (1.28)		
	51.0	29.0	11.0	9.0	21,472			10.30 (1.15)	
	38.6	40.8	9.4	11.2	23,716				11.80 (1.20)
2	47.5	24.2	14.6	13.7	46,508	11.20 (1.73)			
	44.1	25.2	13.5	17.2	47,464		9.20 (1.28)		
	42.2	28.6	11.2	18.0	44,643			9.20 (1.15)	
	30.4	37.9	8.9	22.8	48,373				11.70 (1.20)
3	44.2	22.7	14.3	18.8	70,686	10.90 (1.73)			
	41.0	23.7	12.8	22.5	71,092		8.80 (1.28)		
	38.8	26.8	10.6	23.7	67,106			9.30 (1.15)	
	27.1	34.4	8.1	30.4	73,101				11.20 (1.20)

* The corresponding fuel costs are in parenthesis as mills/kwh.

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TABLE VI
COMPUTED PLUTONIUM VALUES FOR BATCH IRRADIATION
IN FIVE SIMULATED REACTORS

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Successive recycle of optimum plutonium quantity with natural uranium, optimized for minimum fuel cost.
Uranium Price Schedule established July 1, 1962; 4.75 percent Use Charge Rate.

Step No.	Isotopic Composition of the Plutonium, w/o				Cumulative Exposure of Recycled Fuel, MWD/T	Plutonium Value* in each Simulated Reactor, \$/gram (fissile)			
	239	240	241	242		APWR	BWR	HWR	OMR
1	68.4	18.4	10.8	2.4	13,871				12.80 (1.75)
	66.8	21.4	9.5	2.3	15,231	11.10 (2.16)			
	65.1	23.4	8.6	2.9	12,252			10.20 (1.72)	
	64.3	22.1	10.5	3.1	13,386		10.30 (1.77)		
	60.2	30.9	6.7	2.2	11,438			11.20 (1.98)	
2	49.3	24.9	17.4	8.4	29,225				13.20 (1.75)
	45.8	28.6	15.6	10.0	27,211		10.20 (1.77)		
	45.5	32.0	12.7	9.8	25,057			10.30 (1.72)	
	39.8	32.5	16.7	11.0	44,016	9.70 (2.16)			
	31.6	47.6	11.2	9.6	23,708				13.00 (1.98)
3	39.9	24.3	19.4	16.4	46,646				12.10 (1.75)
	38.5	28.0	16.2	17.3	40,260		9.30 (1.77)		
	36.4	32.6	13.3	17.7	88,296			9.70 (1.72)	
	29.4	32.7	17.9	20.0	68,293	7.00 (2.16)			
	19.5	49.3	11.9	19.3	36,445				12.90 (1.98)

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* The corresponding fuel costs are in parenthesis as mills/kwhe.

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TABLE VII

COMPUTED PLUTONIUM VALUES FOR GRADED IRRADIATION
IN TWO SIMULATED REACTORS

Successive recycle of optimum plutonium quantity with natural uranium, optimized for minimum fuel cost.
Uranium Price Schedule established July 1, 1962; 4.75 percent Use Charge Rate.

Step No.	Isotopic Composition of the Plutonium, w/o			Cumulative Exposure of Recycled Fuel, MWD/T	Plutonium Value* in each Simulated Reactor, \$/gram (fissile)	
	239	240	241		HWR	GCR
			242			
1	51.3	27.6	11.9	23,505		11.20 (1.20)
	51.0	27.6	11.9	23,963	7.50 (1.13)	
2	38.2	27.6	13.0	45,778		9.60 (1.20)
	37.5	27.5	13.0	47,043	5.50 (1.13)	
3	31.3	24.6	12.2	66,601		6.80 (1.20)
	30.8	24.4	12.1	67,762	4.10 (1.13)	

* The corresponding fuel costs are in parenthesis as mills/kwh_e.

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TABLE VIII
COMPUTED U-233 VALUES FOR BATCH IRRADIATION
IN FIVE SIMULATED REACTORS

Successive recycle of self-produced U-233 with cascade uranium enrichment of thorium, optimized for minimum fuel cost. Uranium Price Schedule established July 1, 1962; 4.75 percent Use Charge Rate.

Step No.	Isotopic Composition of Recycled Uranium, w/o				Cumulative Exposure of Recycled Fuel, MWD/T	U-233 Value* in each Simulated Reactor, \$/gram (fissile)			
	233	234	235	236		APWR	GCR	OMR	BWR
1	94.8	5.0	0.2	0.0	15,339	13.80 (2.63)			
	94.2	5.5	0.3	0.0	13,526		13.60 (2.35)		
	93.8	5.9	0.3	0.0	17,649			13.10 (2.30)	
	92.6	7.0	0.4	0.0	15,492				14.00 (2.00)
	92.3	7.3	0.4	0.0	16,174				13.50 (1.89)
2	89.9	9.3	0.7	0.1	31,513	13.30 (2.63)			
	88.6	10.5	0.9	0.0	27,066		13.50 (2.35)		
	88.6	10.5	0.8	0.1	34,740			13.10 (2.30)	
	86.1	12.6	1.2	0.1	31,055				13.80 (1.89)
	85.9	12.8	1.2	0.1	31,626				14.10 (2.00)
3	85.6	13.1	1.2	0.1	47,033	13.20 (2.63)			
	84.1	14.4	1.4	0.1	51,102			13.10 (2.30)	
	83.6	14.7	1.6	0.1	40,478		13.50 (2.35)		
	80.7	17.2	2.0	0.1	46,496				13.90 (1.89)
	80.0	17.8	2.0	0.2	48,432				14.00 (2.00)

* The corresponding fuel costs are in parenthesis as mills/kwh_e.

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TABLE IX
COMPUTED U-233 VALUES FOR GRADED IRRADIATION
IN THREE SIMULATED REACTORS

Successive recycle of self-produced U-233 with Cascade uranium enrichment of thorium, optimized for minimum fuel cost. Uranium Price Schedule established July 1, 1962; 4.75 percent Use Charge Rate.

Step No.	Isotopic Composition of Recycled Uranium, w/o			Cumulative Exposure of Recycled Fuel, MWD/T	U-233 Value* in each Simulated Reactor, \$/gram (fissile)		
	233	234	235	236	HWR	BWR	GCR
1	89.0	10.2	0.8	0.0	22,479	14.20 (1.57)	
	88.1	10.9	0.9	0.1	24,353	13.90 (1.70)	13.40 (1.79)
	87.4	11.4	1.1	0.1	23,515		
2	79.5	18.2	2.1	0.2	46,959	14.10 (1.57)	
	78.9	18.7	2.2	0.2	48,341	13.80 (1.70)	13.40 (1.79)
	78.2	19.1	2.4	0.3	45,802		
3	72.9	23.5	3.2	0.4	72,143	14.00 (1.57)	
	72.5	23.9	3.2	0.4	72,489	13.70 (1.70)	13.30 (1.79)
	72.2	23.9	3.5	0.4	68,778		

* The corresponding fuel costs are in parenthesis as mills/kwh_e.

Combined Cycles Studies

A pilot combined cycles study has been planned and is outlined in Table X. It has been designed to show the impact of the isotopic composition of plutonium on the optimization of reactor lattices employing plutonium fuels. Interaction between fuel type and economic climate is expected, therefore, the economic parameters are to be varied to reflect the possible future trends in economic climate as well as the present values. Details of the fuel element geometry, such as the location of the plutonium within the fuel element, is important in such studies, but it will not be fully investigated now because an accurate portrayal of the geometrical shielding effects on plutonium cross sections is very costly with the present code arrangement. The basic fuel element piece is standardized as a one-half-inch diameter UO_2 rod appropriately arranged in groups in accordance with the moderator system being analyzed. Attempts will be made to account for the effects of geometry to the extent allowed by the present codes. The non-fuel absorptions are appropriately flux and volume weighted by Jason code which utilizes the P-3 approximation to solve the Boltzman equation for the distribution of the thermal flux. This flux weighting is, of course, dependent primarily on the fuel element diameter, lattice geometry, the blackness of the fuel to incident neutrons, and the relative amount of moderator which affects the energy distribution of the thermal neutrons. A fair number of cases has been set up for the three reactor types of Table X and are being processed as computer time becomes available.

Code Development

A case generator is being added to the combined cycles chain to facilitate input preparation, and will minimize the probability of errors of a clerical nature because the amount of input data is reduced by a factor of about a hundred. A special master chain version of the code system has been written which allows substitution or additions of new codes to an existing chain of codes without reassembling the entire sequence of codes.

Salt Cycle Economics

Compilation of the revised Conventional Reprocessing Code for economics studies of fuel reprocessing was completed and debug runs were started. A number of errors have shown up and have been corrected. Numerous hand calculations remain to be done to complete the checking and debugging of this code. When completed, this code will provide the base case comparison for the Salt Cycle Economics Code (completed last month) to evaluate economic incentives for developing close-coupled Salt Cycle-type processes.

TABLE X

OUTLINE OF
A STUDY OF THE IMPACT OF FUEL TYPE IN THREE GENERALIZED
TYPES OF REACTORS WITH VARIED ECONOMICS

Reactor Types (No. is used below as a subscript.)

- | | |
|---|------------------------------------|
| 1 | Light water moderated and cooled. |
| 2 | Heavy water moderated and cooled. |
| 3 | Graphite moderated, sodium cooled. |

Moderator Temperatures

$$T_1 = 260 \text{ C}$$

$$T_2 = 100 \text{ C}$$

$$T_3 = 500 \text{ C}$$

Specific Power

15 MW/T, 30 MW/T

Fuel Element Description

Oxide fuel diameter 0.500".
Clad thickness 0.010".
Clad Material Zr, SS, Hastelloy.

Lattice Arrangement

1. Hexagonal array with pitch varied.
2. Nineteen-rod cluster in pressure tube; tube spacing varied.
3. Nineteen-rod cluster cooled with sodium in zirconium pressure tube; tube spacing varied in graphite moderator lattices varied to produce a moderator index range of approximately 0.75 to 5.0, where moderator index is the slowing down power of the moderator per unit fuel volume.

Fuels (Phase I)

U-235 in UO₂. From diffusion cascade UO₂ density 95 percent of theoretical. Percent enrichment varied to achieve minimized fuel costs.

Plutonium in UO₂. Containing U-235 in naturally occurring ratio. (Plutonium enrichment varied to achieve minimum fuel costs, plutonium source compositions are (a) 95 percent 239, 5 percent 240; (b) 70 percent 239, 18 percent 240, 11 percent 241, 1 percent 242; (c) 31.3 percent 239, 33.6 percent 240, 25 percent 241, 10.1 percent 242.)

Fueling Methods. Batch loading and graded loading.

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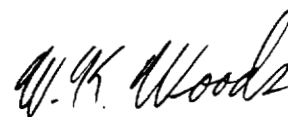
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MISCELLANEOUS

Hanford Science Colloquium

Professor Francis Birch, Chairman of the Department of Geological Sciences of Harvard University was the Hanford Science Colloquium speaker for August 29. The lecture was titled, "The Internal Constitution of the Earth."



Manager,
Programming

WK Woods: jm

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RADIATION PROTECTION OPERATION
REPORT FOR THE MONTH OF AUGUST, 1962

A. ORGANIZATION AND PERSONNEL

Transfers within the Section during the month included Roy F. Ballard transferring from Radiation Monitoring to Environmental Studies and Evaluation, and Jack D. Mixon transferring from Environmental Studies and Evaluation to Radiation Monitoring. Betty B. Hanson began a leave of absence. Flordeliz I. Ambrocio transferred from Construction Engineering and Utilities Operation to Radiation Monitoring. Geraldine B. Lage and Rose W. Kron transferred from External Dosimetry to Contract and Accounting and Construction Engineering and Utilities, respectively. R. W. Hatfield resigned from the Company.

B. ACTIVITIES

Occupational Exposure Experience

Five new cases of plutonium deposition were confirmed by bioassay analyses during August. The total number of plutonium deposition cases that have occurred at Hanford is 297, of which 214 are currently employed. The new plutonium deposition cases resulted from five previously reported radiation incidents (May and June) involving four CPD employees at the 234-5 Building and one HLO employee at the 231-Z Building. In each case, inhalation was attributed as the mode of intake, and the plutonium body burden was estimated to be less than one percent of the permissible body burden.

A CPD process operator received a plutonium nitrate contaminated injury at the Purex facility. The employee was cleaning the floor of the N-cell hood when an unknown object punctured his left ring finger between the second and third joints. Initial examination of the injury with the plutonium wound counter showed 0.014 μC plutonium. After medical excision of tissue, 7×10^{-4} μC plutonium remained at the wound site. A wound counter measurement of the excised tissue showed 0.011 μC plutonium. DTPA was administered by an industrial physician about three hours after the injury occurred and again after 48 hours. This employee had previously received plutonium contaminated injuries in 1960 and 1961, resulting in a plutonium body burden estimated to be less than ten percent of the permissible body burden.

One week after the described incident, the above employee reported for a routine re-examination of the injury with the wound counter. In addition to this measurement, which showed 4×10^{-4} μC plutonium, a scan of the employee's hands was made with the wound counter, according to a newly instituted procedure. The procedure resulted in the detection of 0.042 μC of plutonium on the top of his left little finger. Visual examination of the contaminated area revealed the presence of a small scratch-type injury which had partially healed. Tissue excision was performed and a wound count indicated complete

removal of the plutonium. DTPA was administered after the tissue excision and again on the following day. Investigation failed to provide an explanation of when or where this contaminated injury may have occurred. The employee was unaware of the scratch on his little finger and his only work assignment for the one-week period had been in the Purex control room. There was no evidence to link the injury to the puncture wound received in the N-cell hood. It is not yet possible to provide an estimate of the magnitude of the total plutonium deposition in the body because of the effect of the DTPA treatment.

In addition to the above incident, there were two incidents at the 234-5 Building and three incidents at the 231-Z Building that required special bioassay sampling for plutonium analysis for seven employees.

Three IPD employees were exposed to unknown dose rates at the 105-F reactor while attempting to charge a poison tube during reactor operations. The incident was similar to the one that occurred at the 105-B reactor last month. The charge machine broke free from the ball valve assembly, permitting a backflow of irradiated aluminum and poison pieces. Evaluation of the employees' film dosimeters substantiated the dose estimates provided by gamma pocket dosimeters and indicated that the maximum dose received was about 0.2 r. Under the conditions that existed at the time the men were exposed, there was no possibility of a void in the water column of the tube.

Two HLO pipefitters entered the process cell of PRTR through an emergency exit with the reactor operating at 60 Mw. The employees, whose total time in the process cell was estimated to be two minutes, were unaware that the reactor was operating. Evaluation of their film dosimeters indicated a maximum dose of about 0.05 r.

A rupture of a MgO-PuO₂ fuel element caused the shutdown of the PRTR. Dose rates in A-cell increased from their normal levels of 5-10 mr/hour to 2-4 r/hour. Selected locations on the primary system piping showed dose rates up to 100 r/hour. Discharge of the ruptured element was accomplished in a dose rate of 1 r/hour at ten feet. The water in the discharge pit was contaminated to 2.5×10^{-2} μ c beta/cc. Spectrometric analysis of the discharge pit water indicated the presence of expected fission products. Examination of the ruptured element indicated about 9-1/4 inches of the core, containing an estimated 1.75 grams of plutonium oxide, was missing.

A technologist and a radiation monitor in the Hanford Laboratories received nasal contamination during the unpackaging of metallic coupons in the 242-B Building. Examination in the Whole Body Counter indicated less than five percent of the maximum permissible body burden for Co⁶⁰.

A 16-ton cask containing irradiated material samples was found to have smearable contamination up to 1.8 rads/hour when it arrived on a common carrier from Idaho Falls. The truck bed and undercarriage of the truck were contaminated

up to 5 rads/hour. Surveys of involved personnel, receiving and transfer areas, public roads in the nearby Hanford environs, and a parking lot at Baker, Oregon, indicated no spread of contamination. Decontamination of the cask and the trailer was initiated locally.

On August 10, 1962, approximately 8000 new film badge dosimeters were distributed for routine use throughout HAP0. This distribution also included the exchange of nearly 8000 new security credentials. In the course of making the transition between the new and old badge processing machines, about 1500 film packets were developed in error without being exposed to X-ray identification in the badge processing machine. About one-third of the involved film packets were identified by the gamma radiation received by the wearer. Another one-third of the film packets were identified with people who work in areas where the maximum dose received is less than 0.12 r. The exposure records of these employees were credited with the maximum dose for their assigned area. The remaining cases were individually evaluated through investigation and use of supporting pocket dosimeter measurements.

Environmental Experience

The presence of fallout materials on air filter samples throughout the Pacific Northwest showed a sharp increase on August 31; $30 \mu\text{c}/\text{m}^3$ as compared to an average of $3.2 \mu\text{c}/\text{m}^3$ for July.

A total of 332 biological and produce samples were obtained for radiochemical analysis:

- 49 sets of beef thyroids
- 2 samples of Willapa Bay oysters
- 20 samples of pasture grass
- 72 samples of milk
- 18 samples of vegetables, fruit and meat
- 3 samples of wheat
- 1 sample of baby food
- 167 fish from sampling locations at Priest Rapids, Hanford, Ringold, Richland, Burbank and McNary Dam

Special river samples were taken on two occasions in response to notification of unusually severe ruptures by IPD. Although there was an abnormal release of fission products in one case, the concentrations of fission products in the river were far below action levels.

Studies and Improvements

Fifty-three prints on the design of the Fuels Recycle Pilot Plant were approved during August. Design completion was rescheduled for November 1

due to the addition of the waste calcination program to the project. As a result of the waste calcination program, two design changes of radiological interest were necessary. The low bay cell floor was lowered to the -10-foot level and the first stage high efficiency filters will probably be moved from the cells to the damper pit. Although there is some concern that filter change-out will be more difficult with filters located in the damper pit, the operating groups feel the advantages of the equipment placement within the hood, to be gained by the change in filter location, merit this change.

Calculations of the fission product activity from 12.5 tons of Hanford production fuel, a proposed waste calcination load, indicates this to be a more intense radiation source than the PRTR fuel element for which the cell shielding calculations were based. It was agreed that a two-ton fuel load will be used for initial startup in the calcination process with increases to be made if the shielding provided is adequate.

The mechanical components of the automatic densitometer were inspected and re-aligned as necessary. Several misalignments in assembly of the gear train which provides film positioning required correction.

The new film dosimeter processing machine was used routinely for processing the second set of new Hanford personnel dosimeters. Approximately 40,000 dosimeters were processed by the machine during the last two months. The minor difficulties encountered during its early operation were corrected.

Studies of the 3705 Building layout and work flow were initiated. An improved work flow chart for processing film dosimeters is being designed. Minimum handling of dosimeters will be emphasized.

Arrangements for use of the Sandia Pulse Reactor facility were temporarily postponed. Contract difficulties were encountered in negotiating our performance of this work. Arrangements for Hanford dosimetry work at the Sandia facility will be rescheduled for about January 1963.

Tests of the new BF_3 portable double moderators were completed. Instrument scales for attachment to the meter faces were prepared and ordered. These instruments will be ready to place in the portable pool for field use as soon as the BF_3 tubes are supplied by the instrument fabrication shop.

Instrument specifications for alpha, beta, gamma hand and shoe counters are being completed for the next purchase of these instruments. Some minor deficiencies in the current prints were noted by the vendor currently building seven of these units. Functional specifications for signalling dose alarms were prepared and readied for comments from other departments. Specifications for the purchase of image storage oscilloscopes and other data recording components to provide additional mechanized pencil reading capabilities were prepared.

The silicon diode neutron dosimeter studies were directed to determine the most sensitive constant voltage for readout and to compare the sensitivity of constant voltage versus constant current readout techniques. The diodes appeared to be most sensitive when a constant voltage of 1.5 V was used. The constant voltage readout technique continues to give the most sensitivity and future diode studies will use this method of readout.

A contract with Battelle Memorial Institute was approved for the manufacture of further experimental silicon diodes. The new diodes will be used to study the sensitivity of both n- and p-type silicon. Delivery is scheduled for November 1962.

All 65 of the Scintrans ordered last fiscal year were delivered. The instruments passed the inspection tests and appear to be in satisfactory condition. All Scintran instruments are being placed into the portable instrument pool where centralized maintenance will provide improved instrument performance at reduced cost.

An improved alarm system for the Automatic Columbia River Monitoring Station (ACRMS) was installed at the 3701-L Badgehouse. It identifies the type of signal immediately and expedites taking appropriate action.

The potential radiological effects of Hanford operations on land south of the 300 Area were evaluated. Results of this study were incorporated in overall recommendations for land utilization which were provided to AEC-HOO.

An investigation composed mostly of literature review and private communications was conducted regarding the variation of sodium levels in man. It was concluded from the information obtained that a variation of ten percent or less would be expected in either the total body or blood sodium levels among normal individuals.

C. VISITS AND VISITORS

Visitors consulting with members of the Radiation Protection Operation during the month included:

- J. Naidu - Atomic Energy Authority of India, Bombay, India
- D. Jacobs - Research Health Physics, Oak Ridge, Tennessee
- C. L. Osterberg - Department of Oceanography, Oregon State University,
Corvallis, Oregon
- D. K. Mecklam - U. S. Civil Service Commission
- M. R. Keegan)
- C. G. Wills) - Nuclear Engineering Trainees, AEC-HOO
- A. D. Toth)
- C. E. Newton - Walter Reed Army Medical Center, Washington, D.C.

Visitors who toured Radiation Protection Operation facilities during the month included:

- 40 Summer Institute for Radiation Biology people from Washington State University, Pullman, Washington
- 25 High School Science Teachers attending the Hanford Science Seminar

Members of the Radiation Protection Operation visiting off-site during the month included:

- R. F. Foster - Presented invited paper at USPHS Third Seminar on Biological Problems in Water Pollution, Cincinnati, Ohio
- J. M. Selby - Presented paper at American Industrial Hygiene Association meeting in Seattle, Washington

D. RELATIONS

Eight suggestions were submitted by personnel of the Radiation Protection Operation during August. Two suggestions were rejected; none were adopted. Eight suggestions are pending evaluation.

Two radiation orientation meetings and one refresher training session were conducted for customer organizations. Analytical laboratory personnel were trained in counting techniques associated with PRTR. Seventy-four persons attended the Disaster Level Monitoring courses presented at 100-D Area; to date a total of 253 persons have attended the course.

Safety meetings were held throughout the Section during the month of August.

E. SIGNIFICANT REPORTS

- HW-72229 REV - "Dose Rate Measurements of Beaches and Islands on the Columbia River Between Ringold and Richland" by D. McConnon.
- HW-73891 REV - "A Method for Immediate Detection of High Level Neutron Exposure by Measurement of Sodium-24 in Humans" by R. H. Wilson.
- HW-74307 7 - - "Radiological Status of the Hanford Environs for July 1962" by R. F. Foster.
- HW-74811 - - - "Monthly Report for August 1962 - Radiation Monitoring Operation" by A. J. Stevens.

PERSONNEL DOSIMETRY AND RADIOLOGICAL RECORDS

<u>External Exposure Above Permissible Limits</u>	<u>August</u>	<u>1962 to Date</u>
Whole Body Penetrating	0	3
Whole Body Skin	0	3
Extremity	0	2

<u>Hanford Pocket Dosimeters</u>		
Dosimeters Processed	1,969	23,469
Paired Results - 100-280 mr	5	67
- Over 280 mr	0	8
Lost Results	0	0

<u>Hanford Beta-Gamma Film Badge Dosimeters</u>		
Film Processed	9,171	76,610
Results - 100-300 mrad	278	2,517
- 300-500 mrad	16	224
- Over 500 mrad	5	86
Lost Results	40	210
Average Dose Per Film Packet - mrad (ow)	19.43	13.53
- mr (s)	28.81	27.37

<u>Hanford Neutron Film Badge Dosimeters</u>		
<u>Slow Neutron</u>		
Film Processed	1,607	11,323
Results - 50-100 mrem	1	10
- 100-300 mrem	0	29
- Over 300 mrem	0	2
Lost Results	26	61
<u>Fast Neutron</u>		
Film Processed	467	2,952
Results - 50-100 mrem	30	372
- 100-300 mrem	69	488
- Over 300 mrem	0	11
Lost Results	7	22

<u>Hand Checks</u>		
Checks Taken - Alpha	35,768	255,310
- Beta-Gamma	48,959	417,165

<u>Skin Contamination</u>		
Plutonium	35	193
Fission Products	51	369
Uranium	0	12
Tritium	0	0

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Whole Body Counter	Male	Female	August	1962 to Date
GE Employees				
Routine	21	1	22	136
Special	12	0	12	165
Terminal	10	2	12	85
Non-Routine	10	5	15	195
Non-Employees	8	8	16	35
Pre-Employment	0	0	0	8
	<u>61</u>	<u>16</u>	<u>77</u>	<u>624</u>

Bioassay

Confirmed Plutonium Deposition Cases	5	14*
Plutonium - Samples Assayed	262	2,889
- Results Above 2.2×10^{-8} $\mu\text{c}/\text{Sample}$	25	146
Fission Product - Samples Assayed	234	3,509
- Results Above 3.1×10^{-5} $\mu\text{c}/\text{Sample}$	0	15
Uranium - Samples Assayed	230	1,300
Biological - Samples Assayed	3	247
Strontium - Samples Assayed	0	299

Uranium Analyses

Sample Description	Following Exposure			Following Period of No Exposure		
	Units of 10^{-9} $\mu\text{c U/cc}$		Number Samples	Units of 10^{-9} $\mu\text{c U/cc}$		Number Samples
	Maximum	Average		Maximum	Average	
Fuels Preparation	3.1	2.2	62	21.1	1.6	53
Fuels Preparation**			0			0
Hanford Laboratories	13.9	2.4	54	13.2	1.8	39
Hanford Laboratories**			0			0
Chemical Processing	1.9	1.6	2	2.0	1.5	2
Chemical Processing**			0			0
Special Incidents	11.3	4.3	4			0
Random	2.0	1.3	13			0

<u>Tritium Samples</u>	<u>Maximum</u>	<u>Count</u>	<u>August Total</u>
Urine Samples			
> 5.0 $\mu\text{c}/\text{l}$	68.7	257	
< 1.0 $\mu\text{c}/\text{l}$		26	
Samples Assayed			390
D ₂ O Samples			
Moderator	775.3 $\mu\text{c}/\text{ml}$	8	
Primary Coolant	263.6 $\mu\text{c}/\text{ml}$	8	
Reflector	804.5 $\mu\text{c}/\text{ml}$	8	
Samples Assayed			24
Other Water Samples			
Stack Condensate 8-6-62	5.38 $\mu\text{c}/\text{ml}$		<u>125</u>
			539

*The total number of plutonium deposition cases which have occurred at Hanford is now 297, of which 214 are currently employed.

**Samples taken prior to and after a specific job during work week.

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Calibrations

	<u>Number of Units Calibrated</u>	
	<u>August</u>	<u>1962 to Date</u>
Portable Instruments		
CP Meter	1,074	8,106
Juno	315	2,225
GM	581	4,473
Other	174	1,510
Audits	<u>115</u>	<u>843</u>
	2,259	17,157
Personnel Meters		
Badge Film	1,128	13,024
Pencils	-	12,670
Other	<u>516</u>	<u>3,333</u>
	1,644	29,027
Miscellaneous Special Services	1,305	8,584
Total Number of Calibrations	5,208	54,768


Manager
RADIATION PROTECTION

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FINANCE AND ADMINISTRATIONACCOUNTINGCost Accounting

The operating cost control budget was adjusted in August to reflect amounts allocated from the Product Departments for 02 and 03 research and development programs. The operating cost budget, which is based on an interim financial plan, has not been allocated to sections within Hanford Laboratories pending passage of the Appropriations Act by Congress and establishment of firm authorizations by the Atomic Energy Commission.

A cost study pertaining to fabrication costs of UO₂-PuO₂ fuel elements for the Plutonium Recycle Test Reactor was completed. Both the swaging method and the high energy vibration compaction method were analysed. Material cost, excluding SS material, accounts for 55% to 60% of the estimated shop cost.

A pocket-size booklet containing a summary of the Budget for FY 1964 and Revision of Budget for FY 1963 was distributed to Hanford Laboratories' management.

A narrative report has been prepared and published outlining the significant fiscal highlights of FY 1962 for Hanford Laboratories.

Special request activity during the month was as follows:

Accounting
CodeActivity

.1Q	Development of Ultrasonic Testing of Fuel Sheath Tubing for USAEC/AECL cooperative program - an additional authorization of \$58,000 was received, increasing the total authorization for FY 1963 to \$90,000.
.3G	Burst Test of Irradiated Zircaloy Pressure Tube for USAEC/AECL - a new program with authorization of \$1,000 to perform the work.

In connection with the transfer of certain maintenance functions from Fuels Preparation Department to Hanford Laboratories, the following organization code changes became effective on September 1, 1962:

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New Codes

7370 - Hanford Laboratories Maintenance Operation
7371 - Instrument Shops
7135 - Facilities Operation
7136 - Building Operation
7137 - Waste Disposal and Decontamination

Canceled Codes

7133 - Facilities Landlord

One new program code was established during the month as follows:

<u>Code</u>	<u>Title</u>	<u>Remarks</u>
.63	UO ₃ Calcination	A specific process technology assignment for CPD.

Three suggestion awards with over \$500 annual savings were reviewed during the month and granted financial approval.

General Accounting

Modification No. 22 to Article IV of Appendix B to the Prime Contract increased the per diem allowance for living expenses to \$13.25 for all persons 12 years and older and to \$6.62 for all those under 12 years of age. The increase was effective retroactively to April 20.

Following is a summary of the status of letters or agreements covering specific actions requiring AEC concurrence:

AT-256	Participation in Standardizing Activities	To AEC 8-8-62
AT-252	Miniature Swine for Colorado State University	Approved 8-13-62

During the month of August billings to completed plant from Work in Progress accounts amounted to \$145,414.

Hanford Laboratories material investment at August 1, 1962 totaled \$24.4 million as detailed below:

(In thousands)

SS Material	\$23 216
Reactor and Other Special Materials	900
Spare Parts	328 -1)
	<u>\$24 444</u>

(1- Includes a reserve established at August 1, 1962 amounting to \$80,454.

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Nuclear materials consumed in research during the month of July totaled \$266,863 - \$247,806 by Hanford Laboratories and \$19,057 by FPD. The following is a detail by program for the Hanford Laboratories portion:

	(In thousands)
2000 Program	\$ 9 607
3000 Program	230 383
4000 Program	7 816
	<u>\$247 806</u>

Laboratory Equipment and Material Pool activity is summarized below:

	Current Month		FY to Date	
	Qty	Value	Qty	Value
<u>Equipment</u>				
Items Received	122	\$107 731	180	\$136 303
Items Withdrawn by Custodians	7	9 820	22	16 159
Equipment reassigned (purchase eliminated)	20	10 048	45	24 749
Equipment on hand at 8-31-62			1 207	661 973 -1)

(1- Includes 129 items valued at \$58,968 which were on loan at 8-31-62.

The material inventory in the Laboratory Pool at month end was comprised of the following:

Beryllium	1 035 grams	\$ 592
Gold	2 182 grams	2 924
Palladium	2 224 grams	2 535
Platinum	1 896 grams	5 537
Clean scrap	45 grams	131
Contaminated scrap	6 703 grams	19 573
Silver	6 615 grams	462
Hafnium	2 939 grams	1 499
Zirconium	5 344 pounds	<u>105 993</u>
		139 246
Add material held for convenience of others		<u>150 622</u>
Total material held at the Pool		<u>\$289 868</u>

Action as indicated occurred on the following projects during the month:

New Money Authorized HL

CAH-866 Shielded Analytical Laboratory	\$4 000
--	---------

During the month the following OPGs were prepared for issuance:

<u>OPG No.</u>	<u>Title</u>
2.3.5	Construction Engineering and Utilities Operation Manager Position Guide
3.2.5	Overtime Lunches
3.3.1	Grievance Procedures
22.1.6	Applied Mathematics Operation
33.9.4	Priority Messages
66.8	Legal and Financial Responsibility
44.7	Design Review Council
44.8	Uniform Drafting Practices
99.6	Mail Services
1.8	Radiation Protection Standards
22.2.5	Applied Mathematics Operation
22.2.8	Finance and Administration Operation
88.1	Management of Property
2.3.4	Hanford Laboratories Manager Position Guide
3.4.11	Reduction of Force - Weekly Salaried Employees
99.5.1	Long Distance Telephone Service
22.3.1	Approval Authorizations
9.2	Procurement of Equipment, Materials, Services, and Supplies
3.4.17	Reduction of Force, Monthly Salaried Employees
*33.2.12	Placement of Employees Disabled by Personal Illness or Off- The-Job Accidents
22.1.1	Hanford Laboratories

*Notice of cancellation issued.

Contracts processed included the following:

SA-234	Sperry Products Inc.
SA-229	J. W. Hoover
CA-347	George W. Watt
SA-232	Wyandotte Chemicals Corp.
SA-233	Turco Products, Inc.
CA-348	M. J. Sinnott
CA-349	Philip L. Walker, Jr.
SA-241	Colorado State University
SA-242	Automatic Sprinkler Corporation of America

Revisions to the Travel and Living Expense Manual included changes in certain approval authorizations required - clarification of responsibility for traveler's cash, tickets and credit cards, and the addition of a section pertaining to living expenses at the point of departure.

Personnel Accounting

The following employees received Patent Awards during the month of August:

<u>Name</u>	<u>HWIR No.</u>	<u>Title</u>
L. A. Bray	1354)	Process for Recovery of Strontium 90
G. L. Richardson	1354)	from Radioactive Waste Solution
A. M. Platt	1354)	
G. Jansen, Jr.	1354)	
R. A. Walker	1385	A Method of Controlling the Strength of Ultrasonic Weld by Automatically Controlling Weld Time.
H. L. Libby	1370)	Segmented Time Reversal Device.
J. T. Russell	1370)	
*R. F. Burch, Jr.	1407	Fabrication of Uranium Dioxide Single Crystal Spheres by Means of Grinding.
F. P. Roberts	1413	Isolation and Purification of Cerium by Anion Exchange.
K. J. Schneider	1419	A Radiantly Heated Spray Concentrator.

*Nonexempt Bargaining Machinist in Tech. Shops.

Number of Hanford Laboratories Employees

<u>Changes During Month</u>	<u>Total</u>	<u>Exempt</u>	<u>Nonexempt</u>
Employees on payroll at beginning of month	1 516	703	813
Additions and transfers in	32	15	17
Removals and transfers out	<u>41</u>	<u>27</u>	<u>14</u>
Employees on payroll at end of month	<u>1 507</u>	<u>691</u>	<u>816</u>

Overtime Payments During Month

	<u>August</u>	<u>July</u>
Exempt	\$ 3 726	\$ 6 695
Nonexempt	<u>18 604</u>	<u>22 392</u>
Total	<u>\$22 330</u>	<u>\$29 087</u>

Gross Payroll Paid During Month

Exempt	\$ 650 083	\$ 667 441
Nonexempt	<u>439 328</u>	<u>436 251</u>
Total	<u>\$1 089 411</u>	<u>\$1 103 692</u>

1230855

Participation in Employee Benefit
Plans at Month End

	August		July	
	Number	Percent	Number	Percent
Pension	1 334	99.0	1 332	99.1
Insurance Plan - Personal	370		376	
- Dependent	1 105	99.7	1 099	99.9
U. S. Savings Bonds				
Stock Bonus Plan	88	37.6	88	38.1
Savings Plan	72	4.8	72	4.7
Savings and Security Plan	1 123	88.2	1 135	88.3
Good Neighbor Fund	989	65.6	989	65.5

Insurance ClaimsEmployee Benefits

	Number	Amount	Number	Amount
Life Insurance	0	\$ 0	1	\$23 129
Weekly Sickness and Accident	10	939	7	820
Comprehensive Medical	41	3 145	32	2 987

Dependent Benefits

Comprehensive Medical	88	7 583	90	7 487
Total	139	\$11 667	130	\$34 423

TECHNICAL ADMINISTRATIONEmployee Relations

Twenty-three non-exempt employment requisitions were filled during August with 22 remaining to be filled.

Approval was received from AEC to conduct Data Processing, Computing - Fortran, Effective Presentation, and Technical Report Writing as evening Company sponsored courses.

Professional Placement

Advanced Degree - Four Ph.D. applicants visited HAPO for employment interviews. Three offers were extended; one acceptance and five rejections were received. Current open offers total two.

BS/MS - During the month five direct placement offers were extended; two acceptances and five rejections were received. Three program offers were made; one acceptance and four rejections were received. Open offers at month's end included three direct placement and six program.

Technical Graduate Program - Two Technical Graduates were placed on permanent assignments; six new members were added to the rolls and four terminated. Current program members total 56.

Technical Information

Revision Number 1 to the classification guide (HW-74048) covering work done for the University of California Lawrence Radiation Laboratory was issued.

ECONOMIC EVALUATIONS

An explanation of the cost conversion used in the supplementary cost analysis of HW-74304, "Calculated Costs of Fabrication of Plutonium-Enriched Fuel Elements" was prepared for Appendix B of the report. The cost conversion consisted of reclassifying about 60 functional costs to variable and fixed classifications suitable for input to a computer program for variation of parameter analysis.

Substantial progress was made on a broad summary exposition of Nuclear Cost Estimating and Electric Utility Economics. The fairly extensive topics of utility capital requirements and sources of funds, financial structure, regulated rate of return, and operating economics were developed.

There were no reported audit activities by C&AO Internal Auditing within Hanford Laboratories during the month.

PROCEDURES

The Business Systems Development Operation analyst assigned to the Hanford Laboratories completed a study of paper work procedures in use in the Technical Shops. His findings and recommendations for improvements are included in a report transmitted to the Manager of Technical Shops.

FACILITIES ENGINEERINGProjects

At month's end Facilities Engineering Operation was responsible for 13 active projects having total authorized funds in the amount of \$2,744,600. The total estimated cost of these projects is \$9,117,000. Expenditures through July 31, 1962 were approximately \$1,600,000.

The following summarizes project activity in August:

Number of authorized projects at month's end -----	13
Number of new projects authorized-----	0

Projects completed -----	0
New projects submitted to AEC -----	0
New projects awaiting AEC authorization -----	1
CAH-977, Facility for Radioactive Particle Inhalation Studies	
Project proposals complete or nearing completion -----	5
Addition to Radionuclide Facilities	
300 Area Retention Waste System Expansion	
Addition to the 222-U Building	
Neutron Calibration Facility, 3745-A Building	
Graphite Machining Shop	

Pages appended to this report provide detailed project status information.

Services

Satisfactory progress was made in the engineering services provided on the following jobs:

- Equipment procurement valued at \$300,000 including eleven requisitions and two special agreements valued at \$6,215 issued during the month
- 306 Building Salt Bath Furnace Alarms
- 300 Area Process Simulation Facility
- Split-half Machine
- Controlled Environment Facility
- 321 Building Tank Farm Fire Alarm System

Pressure system assistance was provided on:

- EDEL-1 Loop modification design
- Quartz glass irradiation capsules
- Quartz glass UO₂ test section
- Titanium irradiation capsules
- PRTR One Tube Prototype loop
- PRTR ion-exchange vessels -

Plant Engineering effort was expended on:

- 327 critical incident alarm planning
- 3760 Display Room lighting
- 325 Circuit breaker replacement
- 325 Vacuum pump replacement
- 231-Z Alarm system standardization

325 Ceramic Fuels map room lighting and electrical service
3702 Proposed ventilation system
325 Office addition - second floor
325 Analytical laboratory glove box installation
308 Vent study

Maintenance and Operation

Costs for July were \$114,976, which represented 77% of the anticipated expenditure. Improvement maintenance cost \$2,000.

The following tabulation summarizes waste disposal operations:

	<u>July</u>	<u>June</u>
Concrete Barrels	2	4
Loadluggers	2	1
Crib Waste	270,000 gal.	300,000 gal.

Drafting

The equivalent of 182 drawings was produced during the month for an average of 21.2 man-hours per drawing.

Major jobs in progress are: 280 ton extrusion press, PRTR as-builts, PRTR shim rod control, electrical resistivity sample holder, scintillation scanner housing, cladding cutter assembly for PRTR, Mark III borescope, glove box and vacuum system, high temperature furnace and fuel element spacer former.

Construction

Activity during the month on construction work under Hanford Laboratories' supervision is given below:

	<u>Hanford Laboratories Unexpended Balance</u>
Orders outstanding beginning of month	\$182 462
Issued during the month (inc. sup. & adj.)	117 851
J. A. Jones Expenditures during month (inc. C.O. Costs)	94 627
Balance at month's end	205 686
Orders closed during month	83 177

UNCLASSIFIED

H-10

HW-74813

Maintenance work orders total four with face value totaling \$17,245.

Construction and maintenance activities completed during August included:

- 144-F Autopsy room modifications
- 309 Analytical laboratory installation
- 325 Twenty-five ton air conditioner installation
- 326 Service island in Room 6A
- 327 Crane wheel and rail replacement
- 328 Renovate men's room
- 306 Ronnengin water filter installation


Manager
Finance and Administration

W Sale:whm

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SEMI-MONTHLY PROJECT STATUS REPORT						HW- 74813	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 8-31-62	
PROJ. NO.	TITLE					FUNDING	
CAH-822	Pressurized Gas Cooled Loop Facility					4241 Operating	
AUTHORIZED FUNDS		DESIGN \$	AEC \$	COST & COMM. TO		\$	
\$ 1,170,000		43,000	15,000	8-19-62		\$ 1,131,715 (IE)	
		CONST. \$1,127,000	GE \$ 1,155,000	ESTIMATED TOTAL COST		\$ 1,170,000	
STARTING	DESIGN	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN	PERCENT COMPLETE		
DATES	CONST.	DIR. COMP. DATE		CONST.	WT'D.	SCHED.	ACTUAL
	8-19-59	7-25-62*		4-29-60			
	10-17-60	12-31-62		12-31-62			
ENGINEER					DESIGN	100	100
TR&AO-MEEO - DP Schively					TITLE I		
MANPOWER					GE-TIT. II		
FIXED PRICE					AE-TIT. II		
COST PLUS FIXED FEE							
PLANT FORCES					CONST.	100	93
ARCHITECT-ENGINEER					PF	1.4	0
DESIGN ENGINEERING OPERATION					CPFF	22.3	91
GE FIELD ENGINEERING					FP	6.6	100
					Gov. Eq.	69.7	93
SCOPE, PURPOSE, STATUS & PROGRESS							
Replacement of faulty ceramic bushing in new heater is progressing. Earliest shipment by 9-1-62.							
First gas bearing blower rescheduled for test on August 27, 1962. Earliest completion date of both units is now estimated to be September 15, 1962.							
* Initial authorization date was December 18, 1958.							

PROJ. NO.	TITLE					FUNDING	
AUTHORIZED FUNDS		DESIGN \$	AEC \$	COST & COMM. TO		\$	
\$		CONST. \$	GE \$	ESTIMATED TOTAL COST		\$	
STARTING	DESIGN	DATE AUTHORIZED	EST'D. COMPL. DATES	DESIGN	PERCENT COMPLETE		
DATES	CONST.	DIR. COMP. DATE		CONST.	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	
					TITLE I		
MANPOWER					GE-TIT. II		
FIXED PRICE					AE-TIT. II		
COST PLUS FIXED FEE							
PLANT FORCES					CONST.	100	
ARCHITECT - ENGINEER					PF		
DESIGN ENGINEERING OPERATION					CPFF		
GE FIELD ENGINEERING					FP		
SCOPE, PURPOSE, STATUS & PROGRESS							
1230861							

SEMI-MONTHLY PROJECT STATUS REPORT						HW-74813	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 8-31-62	
PROJ. NO. 33H-857	TITLE Physical & Mechanical Properties Testing Cell - 327 Bldg.					FUNDING 0290	
AUTHORIZED FUNDS		DESIGN \$ 45,000	AEC \$ --	COST & COMM TO 8-19-62		\$ 339,128	
\$ 460,000		CONST. \$ 415,000	GE \$ 460,000	ESTIMATED TOTAL COST		\$ 460,000	
STARTING DATES	DESIGN 11-2-59	DATE AUTHORIZED 9-22-61*	EST'D. COMPL. DATES	DESIGN 3-15-61	PERCENT COMPLETE		
	CONST. 2-12-62	DIR. COMP. DATE 12-15-62		CONST. 12-15-62	WT'D.	SCHED.	ACTUAL
ENGINEER FEO - KA Clark					DESIGN	100	100
MANPOWER					TITLE I		
FIXED PRICE					GE-TIT. II	100	100
COST PLUS FIXED FEE					AE-TIT. II		
PLANT FORCES					CONST.	100	4# 4
ARCHITECT-ENGINEER					PF		
DESIGN ENGINEERING OPERATION					CPFF	18	25# 25
GE FIELD ENGINEERING					FP		
					Equip.	82	0 0

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities for determining physical and mechanical properties of irradiated materials, and involves the installation of a cell in the 327 Building.

Current estimate of Title I and II costs - \$60,000. Detailed design started 4-1-60. Procurement and construction authorized 9-22-61.

Number of purchase orders required	19 Value (Est.)	\$253,000**
Number of purchase orders placed	19 Value	204,220..

The cell delivery is scheduled for September 1, 1962.

Installation of electrical conduit below cell floor is 25% complete.

Piping is 20% complete.

* Original authorization for design was October 1, 1959.

**Includes delivery charges, inspection and contingency.

A revision to the construction schedule has been prepared, reflecting the late cell delivery. The percentages are based on the revised schedule which has been submitted for approval.

1230862

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 74813	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 8-31-62	
PROJ. NO.	TITLE					FUNDING	
CAH-866	Shielded Analytical Laboratory - 325-B Building					61-a-1	
AUTHORIZED FUNDS	DESIGN \$ 60,000	AEC \$ 546,500	COST & COMM TO 8-19-62		\$ 136,200 (GE)		
\$ 700,000	CONST. \$ 640,000	GE \$ 153,500	ESTIMATED TOTAL COST		\$ 655,000		
STARTING DATES	DESIGN 9-5-59	DATE AUTHORIZED 5-31-60*	EST'D. COMPL. DATES	DESIGN 11-14-60	PERCENT COMPLETE		
	CONST. 6-15-61	DIR. COMP. DATE 11-15-62		CONST. 10-30-62	WT'D.	SCHED. ACTUAL	
ENGINEER					DESIGN	100	100
FEO - RW Dascenzo					TITLE I		
MANPOWER					GE-TIT. II	10	100
FIXED PRICE					AE-TIT. II	90	100
COST PLUS FIXED FEE							
PLANT FORCES					CONST.	100	100
ARCHITECT-ENGINEER					PF	3	1
DESIGN ENGINEERING OPERATION					CPFF	2	0
GE FIELD ENGINEERING					FP	95	100

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow greater capacity for analytical work involving today's more highly radioactive solutions and consists of adding a shielded laboratory to the 325 Building.

Contractor's completion date was extended three days until August 29, 1962.

The major subcontracts, except painting, are nearing completion.

The site has been stabilized and asphalt paving completed.

Two attempts to chlorinate the sprinkler system were unsuccessful.

Most of the field tests and ATP's remain to be completed. A preliminary punch list of 95 items was prepared.

The laboratory furniture has been set in place and services are being run to it.

A tie-in was made of all building services except distilled water.

Work Authority No. CAH-866(3), dated August 9, 1962 authorized the General Electric Company an additional \$4,000 and increased Title III allocation to \$27,000.

* Original authorization for preliminary design was August 12, 1959.

1230863

SEMI-MONTHLY PROJECT STATUS REPORT						HW-74813																																									
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 8-31-62																																									
PROJ. NO. CAH-867	TITLE Fuel Element Rupture Test Loop					FUNDING 58-e-15																																									
AUTHORIZED FUNDS \$ 1,500,000	DESIGN \$ 130,000 CONST. \$ 370,000	AEC \$ 820,000 GE \$ 680,000	COST & COMM. TO 8-19-62 ESTIMATED TOTAL COST		\$ 563,718 (GE) \$ 1,500,000																																										
STARTING DATES DESIGN 8-1-60 CONST. 11-2-60	DATE AUTHORIZED 6-24-60*	EST'D. COMPL. DATES DESIGN 3-15-61 CONST. 10-31-62	PERCENT COMPLETE																																												
ENGINEER TR&AO-MEEO - PC Walkup			<table border="1"> <thead> <tr> <th></th> <th>WT'D.</th> <th>SCHED.</th> <th>ACTUAL</th> </tr> </thead> <tbody> <tr> <td>DESIGN</td> <td>100</td> <td>100</td> <td>100</td> </tr> <tr> <td>TITLE I</td> <td></td> <td></td> <td></td> </tr> <tr> <td>GE-TIT. II</td> <td>91</td> <td>100</td> <td>100</td> </tr> <tr> <td>AE-TIT. II</td> <td>9</td> <td>100</td> <td>100</td> </tr> <tr> <td>CONST.</td> <td>100</td> <td>100</td> <td>99</td> </tr> <tr> <td>PF</td> <td>2</td> <td>100</td> <td>50</td> </tr> <tr> <td>CPFF</td> <td>57</td> <td>100</td> <td>98</td> </tr> <tr> <td>FP (1)</td> <td>10</td> <td>100</td> <td>100</td> </tr> <tr> <td>(2)</td> <td>31</td> <td>100</td> <td>100</td> </tr> </tbody> </table>						WT'D.	SCHED.	ACTUAL	DESIGN	100	100	100	TITLE I				GE-TIT. II	91	100	100	AE-TIT. II	9	100	100	CONST.	100	100	99	PF	2	100	50	CPFF	57	100	98	FP (1)	10	100	100	(2)	31	100	100
	WT'D.	SCHED.	ACTUAL																																												
DESIGN	100	100	100																																												
TITLE I																																															
GE-TIT. II	91	100	100																																												
AE-TIT. II	9	100	100																																												
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CPFF	57	100	98																																												
FP (1)	10	100	100																																												
(2)	31	100	100																																												
MANPOWER			AVERAGE ACCUM MANDAYS																																												
FIXED PRICE			5 2575																																												
COST PLUS FIXED FEE			5 2365																																												
PLANT FORCES																																															
ARCHITECT-ENGINEER																																															
DESIGN ENGINEERING OPERATION																																															
GE FIELD ENGINEERING																																															
SCOPE, PURPOSE, STATUS & PROGRESS																																															
<p>(1) G. A. Grant Company (2) Lewis Hopkins Construction Company</p> <p>This facility is to be used for fuel rupture behavior studies with respect to physical distortion and rate of fission product release.</p> <p>Loop design tests are in progress. Filter plant acceptance tests completed. Filter plant contract complete except for final tie-in to PRTR piping.</p> <p>* Initial authorization was on 10-1-59.</p>																																															

PROJ. NO. CAH-888	TITLE Biology Laboratory Improvements					FUNDING 60-h-1																																					
AUTHORIZED FUNDS \$ 420,000	DESIGN \$ 44,000 CONST. \$ 376,000	AEC \$ 359,500 GE \$ 60,500	COST & COMM. TO 8-19-62 ESTIMATED TOTAL COST		\$ 60,386 (GE) \$ 420,000																																						
STARTING DATES DESIGN 8-8-60 CONST. 7-10-61	DATE AUTHORIZED 4-18-61*	EST'D. COMPL. DATES DESIGN 3-31-61 CONST. 8-31-62	PERCENT COMPLETE																																								
ENGINEER FEO - JT Lloyd			<table border="1"> <thead> <tr> <th></th> <th>WT'D.</th> <th>SCHED.</th> <th>ACTUAL</th> </tr> </thead> <tbody> <tr> <td>DESIGN</td> <td>100</td> <td>NS</td> <td>100</td> </tr> <tr> <td>TITLE I</td> <td></td> <td></td> <td></td> </tr> <tr> <td>GE-TIT. II</td> <td>17</td> <td>NS</td> <td>100</td> </tr> <tr> <td>AE-TIT. II</td> <td>83</td> <td>NS</td> <td>100</td> </tr> <tr> <td>CONST.</td> <td>100</td> <td>100</td> <td>99</td> </tr> <tr> <td>PF</td> <td>1</td> <td>100</td> <td>100</td> </tr> <tr> <td>CPFF</td> <td>10</td> <td>NS</td> <td>99</td> </tr> <tr> <td>FP</td> <td>89</td> <td>100</td> <td>100**</td> </tr> </tbody> </table>						WT'D.	SCHED.	ACTUAL	DESIGN	100	NS	100	TITLE I				GE-TIT. II	17	NS	100	AE-TIT. II	83	NS	100	CONST.	100	100	99	PF	1	100	100	CPFF	10	NS	99	FP	89	100	100**
	WT'D.	SCHED.	ACTUAL																																								
DESIGN	100	NS	100																																								
TITLE I																																											
GE-TIT. II	17	NS	100																																								
AE-TIT. II	83	NS	100																																								
CONST.	100	100	99																																								
PF	1	100	100																																								
CPFF	10	NS	99																																								
FP	89	100	100**																																								
MANPOWER			AVERAGE ACCUM MANDAYS																																								
FIXED PRICE			2660																																								
COST PLUS FIXED FEE																																											
PLANT FORCES																																											
ARCHITECT-ENGINEER																																											
DESIGN ENGINEERING OPERATION																																											
GE FIELD ENGINEERING																																											
SCOPE, PURPOSE, STATUS & PROGRESS																																											
<p>This project provides additional space for biological research supporting services, and involves an addition to the 108-F Building.</p> <p>* Original authorization for design was May 3, 1960.</p> <p>**The contractor has the damaged vinyl floor covering in the conference room and secretary's office to remove. Some identical material has been located by the contractor; if in sufficient quantity this will be installed within a few days. The new faucets have been installed in the animal rooms. Taping of cove bases will be by CPFF Construction Services Contractor on AEC work order. The CPFF Construction Services Contractor has completed installation of the radiation handling equipment. As-Built drawings are being prepared and BPF material will be processed as soon as it is received from the AEC.</p>																																											

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 74813			
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 8-31-62			
PROJ.NO.		TITLE				FUNDING			
CAH-916		Fuels Recycle Pilot Plant				4-62-a-3			
AUTHORIZED FUNDS		DESIGN \$ 465,000		AEC \$		COST & COMM TO 8-19-62 \$ 464,800			
\$ 465,000		CONST. \$ -0-		GE \$ 465,000		ESTIMATED TOTAL COST \$ 5,450,000***			
STARTING DESIGN 3-15-61		DATE AUTHORIZED 6-29-62**		EST'D. COMPL. DATES		DESIGN 10-15-62			
DATES CONST. 10-15-62*		DIR. COMP. DATE				CONST. 11-15-64			
ENGINEER FEO - RW Dascenzo						PERCENT COMPLETE			
							WT'D.	SCHED.	ACTUAL
						DESIGN	100	91#	92#
						TITLE I	11	100	100
						GE-TIT. II	89	91#	90#
						AE-TIT. II			
						CONST.	100	0	0
						PF			
						CPFF			
						FP			
MANPOWER						AVERAGE	ACCU MANDAYS		
FIXED PRICE						7	6773		
COST PLUS FIXED FEE									
PLANT FORCES									
ARCHITECT-ENGINEER									
DESIGN ENGINEERING OPERATION									
GE FIELD ENGINEERING									

SCOPE, PURPOSE, STATUS & PROGRESS

This project is to provide a facility to perform a full scope of engineering tests and pilot plant studies associated with fuel reprocessing concepts.

All of the 325 drawings have been issued for comment and 200 for approval. The specifications are 70% complete. These totals and the above per cent complete do not include the waste calcination work.

A new project proposal is being prepared to permit demonstration of the waste calcination program in FRPP.

* Estimated construction starting date for removal of burial ground fill.

**** Original authorization for initiation of design was February 9, 1961. June 29, 1962 is the authorization date for the last design supplement.**

***Including transferred capital property valued at \$100,000.

These figures are from the approved revised design schedule. The rescheduling was necessary due to modifications to FRPP for the waste calcination program. This work includes revision of 95 FRPP drawings, 8 new drawings and cancellation of 8 FRPP drawings.

1230865

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 74813	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 8-31-62	
PROJ.NO. CAH-922		TITLE Burst Test Facility for Irradiated Zirconium Tubes				FUNDING 62-k	
AUTHORIZED FUNDS \$ 29,600		DESIGN \$ 29,600 CONST. \$		AEC \$ GE \$ 29,600		COST & COMM TO 8-19-62 \$ 29,600 ESTIMATED TOTAL COST \$ 289,000	
STARTING DATES DESIGN 11-7-61 CONST. 12-15-62		DATE AUTHORIZED 10-23-61 DIR. COMP. DATE		EST'D. COMPL. DATES DESIGN 5-31-62 CONST. 11-1-63		PERCENT COMPLETE WT'D. SCHED. ACTUAL	
ENGINEER FEO - KA Clark						DESIGN 100 100 100 TITLE 1	
MANPOWER				AVERAGE		ACCUM MANDAYS	
FIXED PRICE						GE-TIT. I 57 100 100 AE-TIT. I 43 100 100	
COST PLUS FIXED FEE							
PLANT FORCES						CONST. 100	
ARCHITECT-ENGINEER - Bovay Engineers				260		PF	
DESIGN ENGINEERING OPERATION				260		CPFF	
GE FIELD ENGINEERING						FP	
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project will provide facilities to permit deliberate destructive testing of irradiated zirconium tubing. This will provide operating and tube life data not available because of the limited operating history of Zircaloy-2 pressure tubing in reactors.</p> <p>A meeting has been requested with the Commission to resolve questions developed at the July 19 and 30, 1962 AEC Review Board meetings.</p> <p>No change in status since last report.</p>							

PROJ. NO. CAH-927	TITLE Additions to the 271-CR Building Waste Treatment Demonstration Facility				FUNDING 61-j		
AUTHORIZED FUNDS \$ 92,000	DESIGN \$ 11,000 CONST. \$ 81,000	AEC \$ 76,300 GE \$ 15,700	COST & COMM. TO 8-19-62 \$ 14,888 (GE)		ESTIMATED TOTAL COST \$ 92,000		
STARTING DATES	DESIGN 6-15-61 CONST. 2-15-62	DATE AUTHORIZED 5-15-61 DIR. COMP. DATE 10-31-62	EST'D. COMPL. DATES	DESIGN 2-5-62 CONST. 10-31-62	PERCENT COMPLETE		
ENGINEER FEO - KA Clark				DESIGN	100	100	100
				TITLE I			
MANPOWER				AVERAGE	ACCUM MANDAYS	GE-TIT. II	
FIXED PRICE				6	240	AE-TIT. II	100
COST PLUS FIXED FEE					240		100
PLANT FORCES							
ARCHITECT - ENGINEER					150	CONST.	100
DESIGN ENGINEERING OPERATION						PF	
GE FIELD ENGINEERING				.4	30	CPFF	33
						FP	67
							79
							76
SCOPE, PURPOSE, STATUS & PROGRESS							
This project provides facilities for pilot plant development of decontamination processes for intermediate level chemical processing plant waste for safe discharge to the plant environs. Design was accomplished by the Bovay Engineers.							
The prefabricated metal building has been erected.							
Electrical conduit is being installed.							
Ventilation equipment installation is about 50% complete.							
* A revised schedule is in preparation.							

SEMI-MONTHLY PROJECT STATUS REPORT						HW - 74813	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 8-31-62	
PROJ. NO.	TITLE					FUNDING	
CAE-936	Coolant Systems Development Laboratory 1706-KE Building Addition					62-k	
AUTHORIZED FUNDS		DESIGN \$ 9,000	AEC \$ 115,000	COST & COMM. TO 8-19-62		\$ 11,800 (AE)	
\$ 130,000		CONST. \$ 121,000	GE \$ 15,000	ESTIMATED TOTAL COST		\$ 130,000	
STARTING DATES	DESIGN 9-8-61	DATE AUTHORIZED 4-5-62*	EST'D. COMPL. DATES	DESIGN 1-1-62	PERCENT COMPLETE		
	CONST. 5-1-62	DIR. COMP. DATE 12-31-62		CONST. 12-31-62	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	100
FEC - KA Clark					TITLE I		
MANPOWER			AVERAGE	ACCUM MANDAYS	GE-TIT. II	100	100
FIXED PRICE			6	290	AE-TIT. II		
COST PLUS FIXED FEE					CONST.	100	37
PLANT FORCES					PF		
ARCHITECT-ENGINEER				166	CPFF		
DESIGN ENGINEERING OPERATION					FP	100	37
GE FIELD ENGINEERING			.4	14			
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project provides facilities for the conduct of corrosion and decontamination studies for nuclear reactor coolant systems, by the addition of 2,700 sq. ft. laboratory facility on the west side of the 1706-KE Building. Design was accomplished by the Bovay Engineers. Current estimate of Title I and II costs - \$11,800.</p> <p>Roof decking and ventilation enclosure is under construction.</p> <p>Directive No. AEC-198, Mod. 3, extended the completion date to 12-31-62.</p> <p>* Original authorization for design 8-9-61.</p>							

PROJ. NO.	TITLE					FUNDING	
OSH-951	A-C Column Facility - 321 Building					0290	
AUTHORIZED FUNDS		DESIGN \$ 5,000	AEC \$ -0-	COST & COMM. TO 8-19-62		\$ 29,170	
\$ 55,000		CONST. \$ 50,000	GE \$ 55,000	ESTIMATED TOTAL COST		\$ 55,000	
STARTING DATES	DESIGN 1-30-62	DATE AUTHORIZED 1-12-62	EST'D. COMPL. DATES	DESIGN 4-1-62	PERCENT COMPLETE		
	CONST. 3-15-62	DIR. COMP. DATE 10-31-62		CONST. 10-31-62	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	100
FEO - OM Lyso					TITLE I		
MANPOWER			AVERAGE	ACCUM MANDAYS	GE-TIT. II	100	100
FIXED PRICE					AE-TIT. II	0	
COST PLUS FIXED FEE					CONST.	100	65
PLANT FORCES				185	PF	100	65
ARCHITECT - ENGINEER					CPFF		
DESIGN ENGINEERING OPERATION					FP		
GE FIELD ENGINEERING							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project will provide a closely integrated "A" Column in series with the re-located "C" Column to permit the development of a mathematical model for the mass transfer of uranium, as well as the exploration of the possibilities of computer optimization of a combined "A-C" extraction battery.</p> <p>Relocation of "C" Column is complete. Instrument line gutters are installed. Miscellaneous interconnecting piping work is continuing. "A" Column fabrication and installation work is continuing.</p> <p>Bids have been reviewed and accepted for process stream temperature control, flow control, pH control and variable speed drive speed control instrumentation systems.</p>							

SEMI-MONTHLY PROJECT STATUS REPORT						HW- 74813	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 8-31-62	
PROJ. NO.	TITLE					FUNDING	
GE-955	Reactivation of the H-1 Loop - 105-H Building					0490	
AUTHORIZED FUNDS		DESIGN \$ 10,000	AEC \$	COST & COMM. TO 7-1-62		\$ 2.614	
\$ 10,000		CONST. \$	GE \$ 10,000	ESTIMATED TOTAL COST		\$ 105,000	
STARTING DATES	DESIGN 4-15-62	DATE AUTHORIZED 3-29-62	EST'D. COMPL. DATES	DESIGN 8-30-62	PERCENT COMPLETE		
	CONST.	DIR. COMP. DATE		CONST.	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	
FEO - OM Lyso					TITLE I		
MANPOWER					GE-TIT. II		
FIXED PRICE					AE-TIT. II		
COST PLUS FIXED FEE							
PLANT FORCES					CONST.	100	
ARCHITECT-ENGINEER					PF		
DESIGN ENGINEERING OPERATION					CPFF		
GE FIELD ENGINEERING					FP		
AVERAGE					ACCUM MANDAYS		
<p>SCOPE, PURPOSE, STATUS & PROGRESS</p> <p>This project will provide the primary test facility for determination of the feasibility of using aluminum-clad fuel elements in high temperature water by studying improved alloys and corrosion inhibitors.</p> <p>Design work has been stopped. A project proposal, requesting cancellation of this project has been routed for signatures.</p>							

PROJ. NO.	TITLE					FUNDING	
GE-957	Small Particle Technology Laboratory - 325 Building					62-k	
AUTHORIZED FUNDS		DESIGN \$ 2,000	AEC \$ --	COST & COMM. TO 8-19-62		\$ 34,050	
\$ 40,000		CONST. \$ 38,000	GE \$ 40,000	ESTIMATED TOTAL COST		\$ 40,000	
STARTING DATES	DESIGN 4-23-62	DATE AUTHORIZED 3-21-62	EST'D. COMPL. DATES	DESIGN 5-31-62	PERCENT COMPLETE		
	CONST. 7-6-62	DIR. COMP. DATE 11-1-62		CONST. 11-1-62	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	100
FEO - DS Jackson					TITLE I		
MANPOWER					GE-TIT. II	100	100
FIXED PRICE					AE-TIT. II		
COST PLUS FIXED FEE							
PLANT FORCES					CONST.	100	35*
ARCHITECT-ENGINEER					PF	100	35*
DESIGN ENGINEERING OPERATION (HLO)					CPFF		
GE FIELD ENGINEERING					FP		
AVERAGE					ACCUM MANDAYS		
3					40		
0					32.6		
<p>SCOPE, PURPOSE, STATUS & PROGRESS</p> <p>This project provides laboratory space for research and development in small particle technology related to the generation, control, and disposal of radioactive wastes.</p> <p>The concrete block work is about 80 per cent complete.</p> <p>* Project Planning Schedule.</p>							

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SEMI-MONTHLY PROJECT STATUS REPORT						HW- 74813	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 8-21-62	
PROJ. NO.	TITLE					FUNDING	
CAE-958	Plutonium Fuels Testing & Evaluation Laboratory - 308 Bldg.					62-2	
AUTHORIZED FUNDS	DESIGN \$ 15,500	AEC \$ 148,000	COST & COMM TO 8-19-62		\$ 2,000		
\$ 150,000	CONST. \$ 134,500	GE \$ 2,000	ESTIMATED TOTAL COST		\$ 150,000		
STARTING DATES	DESIGN 9-1-62	DATE AUTHORIZED 6-22-62	EST'D. COMPL. DATES	DESIGN 12-1-62	PERCENT COMPLETE		
	CONST. 12-1-62	DIR. COMP. DATE 5-15-63		CONST. 4-15-63	WT'D.	SCHED. ACTUAL	
ENGINEER				FED - OM Lyso			
MANPOWER				AVERAGE	ACCUM MANDAYS		
FIXED PRICE							
COST PLUS FIXED FEE							
PLANT FORCES							
ARCHITECT-ENGINEER							
DESIGN ENGINEERING OPERATION							
GE FIELD ENGINEERING							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project provides for the extension of plutonium research laboratories on the second floor of 308 Building by erection of plastered ceilings and walls to provide contamination control barriers. It also includes laboratory service extension and fabrication of a metallography hood.</p> <p>Work Authority CAE-958 (1) dated July 3, 1962 authorized the General Electric Company \$2,000 to review the project scope and design and to submit a cost estimate in sufficient detail to assure the Commission that costs for the project are reasonable - GE&UC is presently preparing this review.</p>							

PROJ. NO.	TITLE					FUNDING	
CAE-962	Low Level Radiochemistry Building					05-1-63-H-001-23	
AUTHORIZED FUNDS	DESIGN \$ 113,000	AEC \$ 82,000	COST & COMM. TO 8-19-62		\$ 16,500 (AE)		
\$ 113,000	CONST. \$	GE \$ 31,000	ESTIMATED TOTAL COST		\$ 1,200,000		
STARTING DATES	DESIGN 7-23-62	DATE AUTHORIZED 6-28-62	EST'D. COMPL. DATES	DESIGN 5-15-63	PERCENT COMPLETE		
	CONST. 8-1-63	DIR. COMP. DATE --		CONST. 8-1-64	WT'D.	SCHED. ACTUAL	
ENGINEER				FED - KA Clark			
MANPOWER				AVERAGE	ACCUM MANDAYS		
FIXED PRICE							
COST PLUS FIXED FEE							
PLANT FORCES							
ARCHITECT - ENGINEER							
DESIGN ENGINEERING OPERATION				1	26		
GE FIELD ENGINEERING							
SCOPE, PURPOSE, STATUS & PROGRESS							
<p>This project provides a building in which extremely sensitive radioanalyses and methods development can be performed in an atmosphere protected from the environs. It consists of designing and constructing a building housing approximately 22,000 square feet of floor area including the basement.</p> <p>A schedule for the design criteria progress has been submitted to the AEC for approval. Proposed layouts are being prepared based on information furnished by the using component and frequent scope meetings.</p> <p>Information is being furnished by the customer in answer to a design request covering electrical requirements, personnel assignments (by numbers of people), laboratory furniture requirements, room arrangements etc.</p>							

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BM-7300-042(2-61) AEC-GE RICHLAND, WASH * Title I schedule which has been submitted to AEC for approval.

SEMI - MONTHLY PROJECT STATUS REPORT						HW - 74813	
GENERAL ELECTRIC CO. - Hanford Laboratories						DATE 8-31-62	
PROJ. NO.	TITLE					FUNDING	
CAH-963	Geological & Hydrological Wells - FY-1962					62-k	
AUTHORIZED FUNDS	DESIGN \$ 1,400	AEC \$ 68,500	COST & COMM TO 8-19-62		\$ 10,318 (GE)		
\$ 80,000	CONST. \$ 78,600	GE \$ 11,500	ESTIMATED TOTAL COST		\$ 80,000		
STARTING DATES	DESIGN 5-18-62	DATE AUTHORIZED 5-9-62	EST'D. COMPL. DATES	DESIGN 6-1-62	PERCENT COMPLETE		
	CONST. 7-6-62	DIR. COMP. DATE 4-1-63		CONST. 4-1-63	WT'D.	SCHED.	ACTUAL
ENGINEER					DESIGN	100	100
PEO - HE Ralph					TITLE I		
MANPOWER					GE-TIT. II	100	100
FIXED PRICE					AE-TIT. II		
COST PLUS FIXED FEE							
PLANT FORCES					CONST.	100	38
ARCHITECT-ENGINEER					PF		
DESIGN ENGINEERING OPERATION					CPFF	2	1
GE FIELD ENGINEERING					FP	98	37
							19
SCOPE, PURPOSE, STATUS & PROGRESS							
This project involves the continued drilling of special hydrological research, test and monitoring wells.							
Approximately 900 feet of hole have been drilled to date. Boulders and heavy gravel							

TEST REACTOR AND AUXILIARIES OPERATIONREACTOR DEVELOPMENT - 04 PROGRAMPLUTONIUM RECYCLE PROGRAMPlutonium Recycle Test ReactorOperation

Reactor output was 498 MWD for a plant efficiency of 23% and an experimental time efficiency of 25.8%. The outage, which began June 3, continued until August 5. The reactor was shut down again on August 8-9, to repair a D₂O leak at a spare inlet thermowell. Another shutdown occurred August 12-16, when the diesel generator failed to start automatically on test. The outage was extended to correct helium and D₂O leaks and to rework three galled helium valve stems.

A shutdown occurred August 21, as a result of excessive leakage of hot D₂O into the waste collection system. The source of the D₂O leakage was at the tie-in to the low pressure light water injection system. Approximately 15 minutes after shutdown, a fuel element rupture with gross contamination spread throughout the primary system occurred. Fuel element #5139, a MgO-PuO test element in tube 1356, was discharged and visual examination showed a cladding failure approximately 1½ inches long on an outer fuel rod. Reactor discharge was underway at the end of the month to permit decontamination of the primary system.

Equipment Experience

Mechanical seals on a reflector pump and a moderator pump were replaced because of excessive leakage.

Repairs were required on the fueling vehicle bridge drive control unit. Breakdown was caused by a component failure in the current compensator circuit.

Difficulties were experienced with starting of the diesel generator. Complete analysis indicated a low battery, pitted contacts, insufficient battery recovery time between start attempts. Circuitry changes and improved procedures for inspection of batteries were instituted.

Extensive repairs were required on both water chiller compressors.

The inflatable seals on the thermal barrier were replaced when repairs to the old seals were not possible because of deterioration of the seal material.

Rework of high pressure helium valves was necessary because of galling between stainless steel stem and bodies. Hardened stems and brass bushings were installed to remedy the problem.

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Preventive maintenance required 638 manhours or 12% of total.

Improvement work status (significant items)

Work Completed:

Modification to deep well pump controls
Automatic backup to filtered water reservoir
Revision to DC power for HX-1 liquid level indicating lights
Provision of bottled air backup for emergency depressurization valve
Chain barricade for rotating shield
Fuel transfer hoist pit drain

Work Partially Completed:

Safety circuit ground and low voltage detector
Outlet nozzle cap modification (now 90%)
Fueling vehicle hoist modification
Primary oxygen analyzer installation
Core blanket system piping modifications (interim work complete)
Flanges for safety relief valves in helium system - 85%
Position indicating lights for convection cooling assist valve

Design Work Completed:

Enlarge chemical feed system
Decontamination facility
Primary pump recording ammeters
High pressure helium compressor inter-after cooler relief
Outlet nozzle bracing
Interlock between charge-discharge machine, shroud seat and discharge hoist
Control room ventilation scope
Third exhaust air activity channel
Fuel transfer system modifications
Modification to temperature alarm and data reduction system

Design Work Partially Complete

Additional fuel storage and examination
Oil storage building
Boiler feed pump seals
Compressed air supply revisions

Process Engineering and Reactor Physics

Amperage readings of a vapor bound primary pump were obtained, thereby completing PRTR Test No. 17 (Primary Pump Vapor Binding). No significant difference in amperage was found between vapor bound and normal operation.

A review of test data to determine the minimum cooling air available to a fuel element in the fuel element examination facility regardless of placement of the element was begun.

During the month, valuable experience was gained with the rupture monitor system. Definite fission product bursts and a high background count rate were observed prior to 8/21. The high background count rate, predicted earlier, will be reduced by design changes now being studied.

During these bursts and during the 8/21 rupture, exceptional sensitivity was noticed in the channel which monitored tube 1356, which contained the MgO-PuO₂ rupture element. This high sensitivity may have been caused by either a higher instrument sensitivity than the others or by the monitoring of the particular tube containing the defective fuel element.

Procedures

Revised Operating Procedures issued		18
Revised Operating Standards issued		4
Temporary Deviations to Operating Standards issued		2
Revised Process Specifications accepted for use		0
Maintenance Manuals issued		0
Drawing As-built status	<u>August</u>	<u>Total</u>
Approved for as-built	98	837
Ready for approval		30
In drafting		23
Voided		76
No change required		81
		<u>1 047</u>
Scheduled for review		<u>334</u>
		<u>1 381</u>

Personnel Training

Qualification subjects	210 manhours
Specifications, Standards, Procedures	70 "
Fueling Vehicle	0
	<u>280 manhours</u>

Status of Qualified Personnel at Month-end

Qualified Reactor Engineers	10
Provisionally Qualified Reactor Engineers	1
Qualified Technicians	6
Qualified Technologists	19
Provisionally Qualified Technologists	2

Plutonium Recycle Critical Facility

Additional difficulty was encountered with safety rod sticking. Repair work and subsequent testing indicated satisfactory operation. A moderator dump test, in which a full moderator load of H₂O was dumped through the dump valve into the cell was completed. The cell remained flooded for 24 hours with electrical equipment submerged. No effect on electrical equipment or circuits nor other difficulties were observed. Thirty Pu-Al fuel elements were received and stored in the PRCF cell.

Work was started on an interlock to prevent loss of transfer lock seal air on loss of process water pressure and work was completed on installation of the backup air supply. Design was completed to permit individual rod drops and to remove an interlock from the safety rod system to permit operation. Fourteen manhours were devoted to training.

Fuel Element Rupture Test FacilityProject Status (Project CAH-862)

Construction is 99% complete. The water plant was completed August 10, 1962, with exceptions. Electrical design tests were completed and instrument tests were 90% complete. Design analysis of revisions needed resulting from hazards analyses and testing were started.

Operation

Revisions to the technical manual were completed. Work continued on preparation of operating procedures and qualification questions. Hours devoted to training totaled 154.

Water quality limits for the filter plant were established.

GAS COOLED POWER REACTOR PROGRAMProject Status (Project CAH-822)

The project is 91% complete. Activities were delayed pending receipt of the heater. Heater testing at the vendor's shop resulted in failure of a ceramic bushing at a pneumatic pressure of 1000 psi.

Blower testing continued to result in various difficulties. Final testing was again scheduled for month-end at the vendor's plant.

Work was performed on punch list items.

Operation

Distribution of operating procedures is 14% complete. Ninety manhours were devoted to training.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 20,124 hours. This includes 13,801 hours performed in the Technical Shops, 3,339 hours assigned to Minor Construction, 2,714 hours assigned to off-site vendors, and 270 hours to other project shops. Total shop backlog is 19,737 hours, of which 70 percent is required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 5.3 percent (1,052) of the total available hours.

Distribution of time was as follows:

	<u>Manhours</u>	<u>% of Total</u>
Fuels Preparation Department	3 738	18.57%
Irradiation Processing Department	2 873	14.28%
Chemical Processing Department	766	3.82%
Hanford Laboratories Operation	12 745	63.33%
Construction Engineering and Utilities	2	-

Requests for emergency service increased slightly from the previous month, but within a level which is considered normal for this operation.

MD Richmond

Manager
Test Reactor and Auxiliaries

WD Richmond:bk
September 13, 1962

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INVENTIONS OR DISCOVERIES

All persons engaged in work that might reasonably be expected to result in inventions or discoveries advise that, to the best of their knowledge and belief, no inventions or discoveries were made in the course of their work during the period covered by this report except as listed below. Such persons further advise that, for the period therein covered by this report, notebook records, if any, kept in the course of their work have been examined for possible inventions or discoveries.

<u>INVENTOR</u>	<u>TITLE OF INVENTION OR DISCOVERY</u>
R. J. Henrig	Pump Vanes
J. C. Fox	Nuclear Reactor Control
R. J. Hennig	Nuclear Reactors
R. J. Hennig	Nuclear Reactors Cooles and/or Moderated with Deuterated Organic Compounds
F. R. Zaloudek and T. H. Quinn (IPD)	A Means to Add Algebraically a Number of Nonfloating Voltages
J. C. Spanner	HWIR-1540, A Hall Effect Magnetom- eter for the Nondestructive Testing of Steel
J. T. Russell	HWIR-1549, Radiation Dose Meters
H. L. Libby	HWIR-1548, Eddy Current Nondestructive Testing Device with Graphical Nulling Feature
L. C. Amos	Cyclone Separators
A. C. Leaf	The Solvent Extraction of the Ceric Nitrato Complex from Mixed Fission Product Waste into a Tertiary Amine Using Potassium Dichromate as an Oxidant



Manager, Hanford LaboratoriesUNCLASSIFIED

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