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HANFORD LABORATORIES MONTHLY ACTIVITIES REPORT

AUGUST 1964

SEPTEMBER 15, 1964

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON
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HANFORD LABORATORIES
MONTHLY ACTIVITIES REPORT [redacted]
AUGUST 1964

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HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRELIMINARY REPORT

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*F-1: Programming Operation has been merged with Physics and Instruments Laboratory and Radiation Protection Operation. These groups are now reporting fuel cycle analysis and nuclear health and safety work, respectively.

Table I - Hanford Laboratories Force Report

Date: August 31, 1964

	At Beginning of Month		At Close of Month		
	Exempt	Salaried	Exempt	Salaried	Total
Chemical Laboratory	158	126	157	130	287
Reactor & Fuels Laboratory	215	204	213	204	417
Physics & Instruments Laboratory	129	78	138	81	219
Biology Laboratory	46	65	43	65	108
Applied Mathematics Operation	19	6	17	6	23
Radiation Protection Operation	42	86	42	84	126
Finance & Administration Operation	127	116	126	150	276
Programming Operation	24	6	13	4	17
Test Reactor & Auxiliaries Operation	60	311	59	301	360
General	3	5	2	6	8
TOTAL	823	1003	810	1031	1841

BUDGET AND COST SUMMARY

August operating costs totaled $2,596,000, a decrease of $45,000 from the previous month; fiscal year-to-date costs are $5,236,000 or 15% of the $34,863,000 current control budget for FY 1965.

Hanford Laboratories' research and development costs for August compared with the previous month and the current control budget are shown below:

(Dollars in thousands)	COST Current Month	Previous Month	To Date	Budget	% Spent
HL Programs					
02	$ 56	$ 52	$ 108	$ 542	20
04	1 073	1 092	2 165	15 620	14
05	100	118	218	1 444	15
06	284	308	592	3 570	17
07	4	1	5	---	--
08	43	39	82	280	28
	1 560	1 610	3 170	21 466	15
Sponsored by					
NRD	137	157	294	1 594	18
IPD	13	25	38	425	9
CPD	158	203	361	2 207	16
Total	$1 868	$1 995	$3 863	$25 692	15%

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

A second comparative irradiation test of fuel elements of N-Reactor uranium fuel composition and of elements containing 400 ppm iron and 800 ppm aluminum in the uranium was completed. Postirradiation bulk density measurements show consistently less swelling in the latter case.

A failure occurred in one of two N-Reactor single tube fuel elements with fluted outer surface which were under irradiation in the ETR. The failure, which occurred at an exposure of approximately 2500 Mwd/ton, [redacted]

was adjacent to an end cap and in the vicinity of a marker tab that had been spot-welded onto the cladding surface.

Irradiation testing of fuel fouling detectors fueled with Th-U alloy has been successfully completed. Four detector probes are now in use in N-Reactor.

The 17 uranium alloys to be used in experimental irradiation studies to evaluate the effects of alloying and heat treatment on swelling have been fabricated into Zircaloy-2 clad rods from which test specimens are being prepared.

All target elements for N-Reactor production test NR-8 have been delivered to N-Department. This delivery included 650 full length elements and 135 short target elements. Complete dimensional measurements were made on 108 of the enriched uranium driver tubes to be used in this production test.

Visual examination of a series of lithium-containing ceramic test elements after irradiation testing revealed no evidence of irradiation-induced changes. These elements were irradiated for sufficient time to give calculated gas contents of the test samples (GVR) up to 12.9.

Corrosion testing of defected Li-Al target elements in 280 C water has been completed. In those elements in which the target core was exposed directly to the coolant, swelling caused by corrosion was observed within the first 4 hr and extensive corrosion damage and clad splitting had occurred at the end of the 297 hr test period.

Mechanical testing of closures from hot-headed, projection-welded and brazed elements have given closure strengths in excess of 30,000 psi. Highest strength was obtained from an element having six-ring projections.

Two transient heat transfer experiments were conducted to investigate fuel temperatures following the possible rupture of a main water supply line

[redacted]

at N-Reactor. It was found that with a normal decrease in heat generation rate the maximum temperatures in the test section did not exceed 1100 F.

The time to boil water out of small production reactor process tubes filled with thoria fuel was calculated to be well over a minute for cases where water loss occurred after the reactor had been shut down for some time.

The crud film removed from a portion of the ruptured N-Reactor fuel element was less than 0.05 mil thick and would increase the surface temperature less than 1 C at a heat flux of 500,000 Btu/hr-ft^2.

No stress cracking was found on copper tubing and brass fittings exposed for 5 mo to stagnant pH 9-10 ammoniated water and vapor at 55-150 C, the temperature and pH conditions proposed for the N-Reactor graphite cooling system.

Corrosion evaluation in high temperature water of nickel plating techniques for aluminum and the effects of diffusion heat treatment indicate chemical nickel is superior to electroplates.

Coupons of Zircaloy-2 and 4 were exposed 58 days in-reactor and in out-of-reactor control experiments to a 400 C (752 F) helium atmosphere containing CO, H_2, and water vapor. No evidence of acceleration of the corrosion rate in-reactor was noted.

The first stress rupture test of a section of an irradiated KER pressure tube has been completed. It ruptured in 492 hr at a temperature of 300 C (572 F) and a hoop stress of 61,000 psi. A similar specimen in the unirradiated condition would have been expected to fail at the same stress in 20 hr.

Under certain conditions hydrogen reduces the rate of oxidation of graphite-water vapor by factors of 3-1/2 and 7.

Continuous analysis of effluent gases has been demonstrated as a successful way of determining instantaneous rates of oxidation of graphite by water vapor.

The long term irradiation of N-Reactor graphite in the GETR is progressing satisfactorily.

Three fuel elements were delivered to the PRTR. A short core fuel element, a prototype for possible high power density PRTR testing, was prepared using UO_2-filled rods assembled into a 19-rod cluster.

Swaging and extrusion are being evaluated for fabrication of plutonium alloy wire for enrichment of uranium oxide pellet-filled rods.

A new swage rod loading hood, which incorporates several improvements, was put into service.

Excess oxygen in nonstoichiometric UO_2, introduced both by roasting and by adding U_3O_8, was found to equilibrate among the various UO_2 particle size fractions upon heating under vacuum at 1200 C for 80 min in a double Nupac can.

Examination after 106 hr of operation in the PRTR rupture loop revealed no fuel washout or changes in the appearance of an intentionally defected, preirradiated (240 Mwd/ton), swage-compacted UO_2 fuel element.

Failure in the modified end cap region of a PRTR rod, containing contaminated fuel material, indicates that end cap crevices are not the cause of previous fuel element failures.

Machining appears to enhance susceptibility of PRTR Zircaloy cladding to hydride attack.

The reaction layer on Zircaloy-2 capsules exposed to iodine at 400 C has been identified as alpha-zirconium.

The full length, Mark IX-B UO_2 inverted cluster fuel element was successfully irradiated in the PRTR rupture loop and displayed no visually detectable dimensional changes or surface fouling.

Capsule tests of EBWR UO_2-PuO_2 rods are performing satisfactorily under proposed 42 Mw EBWR conditions (60 w/cm^2 maximum heat flux) and to the exposure of most interest ($\sim 2.5 \times 10^{20}$ fissions/cm^3).

[redacted]

Several dozen specimens of two overlapping Zircaloy strips, 3/16 in. wide by 0.010 in. thick, were spot welded together under water.

Based on visual examination, the aluminum-clad fuel elements from C-1 Loop, which had been exposed in-reactor for 1400 hr to recirculating water at 260 C outlet temperature and pH 4.5 with phosphoric acid, did not appear to have nonuniform corrosion.

A 3/8 in. OD, 0.035 in. wall stainless steel tube, 18 in. long with a 0.110 in. tungsten heater wire down the middle, was vibrationally compacted with UO_2 to 85% TD. This rod is to be used in fuel relocation studies.

Examination of a PuN-15 vol% Pu cermet irradiated to an estimated burnup of 35×10^{20} fission/cm^3 showed that a portion of the specimen was converted to a fine power.

The thermal expansion of a single crystal specimen of UO_2 was measured between 300 and 1600 C.

Irradiation was completed on the first of a series of UO_2 melting tests investigating the effect of stoichiometry on thermal conductivity during and after reactor startup.

A thoria element originally containing 680 ppm nitrate released 180.2 ml of gas, 170 ml of which was N_2, after 1.1×10^{20} nvt exposure in the MTR.

Five irradiated PRTR fuel rods with different fuel fabrication history were transferred to the Radiometallurgy Laboratory for sectioning. Approximately 12 in. rod sections will be slotted, capped, and subjected to simulated reactor coolant flow conditions to develop fuel washout data.

Enriched UO_2-15 wt% PuO_2, densified by pneumatic impaction to 95% TD, shows uniform plutonium distribution by autoradiography and chemical testing.

No gross inhomogeneities in plutonium concentration were found in a sample of UO_2–20% PuO_2 (impacted and 64 hr ball-milled) analyzed by the electron microprobe.

Specifications were written for UO_2 powder to be used in the pneumatic impaction process.

Vibrational compaction loading of fused UO_2 particles in a thin wall Zircaloy-2 clad, tube-in-tube fuel element resulted in greater than 86% TD in both the inner tube and the outer tube.

All six of the small cans of BeO-nickel coated PuO_2 impacted material have been opened. The BeO matrix appeared to be bonded in all of the samples.

A highly loaded UO_2-Nb cermet, clad with thin wall niobium tubing and sealed with powdered niobium end caps was fabricated by pneumatic impaction.

The first use of rectangular tooling in the Dynapak machine was successful.

Previously reported differences in the tensile properties of Inconel X-750 have been shown to result from variations in grain size resulting from the conditions of heat treatment.

Oxidation rate data for Hastelloy-X and Haynes-25 have been obtained at 1120 C (2048 F) in various pressures of oxygen, carbon dioxide, carbon monoxide, and atmospheric pressure air. Rate processes are generally parabolic.

Internal oxidation of cold worked TZM exposed 11 days to 1000 C (1832 F) 5×10^{-4} Torr air was observed; for annealed TZM, penetration was negligible.

Room temperature tensile tests on control specimens of various nickel base alloys exposed to 580 and 740 C (1076 and 1364 F) helium were completed and the data compared to that for specimens irradiated under similar thermal conditions to an exposure of 9×10^{19} nvt.

[redacted]

Preliminary results from high rate loading fracture experiments on AISI A302B SS indicate a possible correlation between fracture phenomena and deformation behavior.

A 10% oxalic acid solution has been used to metallographically confirm the presence of martensite in cold-worked AISI 304 SS.

The special ETR C-7 Loop test with a hydrogen addition to the coolant, which started in July 1964, with a varied charge of corrosion specimens, appears from water analysis to be progressing satisfactorily.

The first controlled pressure-temperature swelling capsule is operating successfully in a reactor at 450 C (842 F) and 1000 psi.

Examination of the replica from a U + Fe-Al specimen irradiated to 0.16 at.% burnup at 605 C (1121 F) showed small pores attached to a few of the second phase particles and almost no matrix porosity or tearing.

The radiation-induced reaction of carbon monoxide with water vapor was found to be very efficiently sensitized by helium. In gas mixtures containing up to 98% helium the yield of products based on total energy absorbed was invariant, with a G value of 15.

The oxidation rates of a highly purified graphite, SP-6, in air and in air with C-Cl_2F_2 inhibitor were found to be greater than rates for EGCR-type graphite. The results are anomalous since the SP-6 material contains a much lower content of vanadium thought to be the oxidation catalyst of importance.

The first boronated graphite samples recovered from the ETR irradiation facility confirmed earlier results obtained in the Hanford reactors.

Increased stiffness in rolling Zircaloy-2 strip has been observed on several occasions when a period of weeks has elapsed in the fabrication schedule, indicating a possible aging process. Laboratory tests show that increased strengths of 3000 to 6000 psi can be achieved by aging; however, these changes do not appear to be sufficient to cause the apparent increases in roll force.

Irradiation of three tubular Zircaloy-2 clad Th-U fuel elements continued successfully in the ETR-P7 loop. Fuel swelling continues to be no more than expected from the solid fission products. The measured volume increase at 8500 Mwd/ton was 0.9%.

Irradiation of a uranium test rod containing a submicron dispersion of uranium carbide in the fuel has been completed. The test capsule has been shipped to Radiometallurgy for examination.

Techniques have been developed for strengthening the beta phase of unalloyed plutonium and for eliminating microcracks in high purity plutonium.

Molybdenum foils having three controlled carbon contents have been examined by X-ray diffraction after irradiation to 1×10^{20} nvt (E > 1 Mev).

Deformation studies in the electron microscope of irradiated molybdenum have demonstrated that moving dislocations interact with defect clusters and form jogs that impede their motion during glide.

Large dislocation loops have been observed by transmission electron microscopy in specimens of irradiated carbon-doped molybdenum that were annealed at 750 C (1382 F) for 2 hr. These loops are interstitial in character. The character of the smaller loops present in these specimens could not be established.

A discontinuity at approximately 110 C (230 F) in the differential thermal analyses heating curve of plutonium has been reported by investigators at the Mound Laboratories. The specific volume-temperature curve of high purity plutonium derived from heating rates of 1 C (34 F) per hour contained no discontinuity between 100 and 119 C (212 and 246 F). In the event of a change in either crystal structure or atomic structure in this temperature range, no volumetric change takes place.

The first shipment of 810 EBWR UO_2-1.5 wt% PuO_2 fuel rods was made to Argonne.

A wet hydrogen, high temperature treatment was found to remove CO_2 and H_2O from UO_2 powder prepared from oxidation of the metal.

[redacted]

Fifty-five of 474 ultrasonically tested Zircaloy-2 cladding tubes gave indications of defects in excess of 0.001 in.

Two UO_2-62 wt% nichrome cermet discs, 0.6 in. diameter, totally clad in nichrome, were prepared by a Nupac technique.

Approximately 7500 20 wt% Pu-Al discs, 0.020 in. thick, have been fabricated to close tolerances by the recently developed spiral machining process.

Discs, containing 3 g/cc UO_2 (~69 wt% UO_2), were formed using an organic binder and carefully controlled heating rates. The 1.9 in. diam by 3/8 in. thick discs machined satisfactorily and the material appears to be suitable for HTLTR control rod sleeves.

Two sample, 3 wt% Pu-Al, I&E fuel elements have been fabricated and nondestructively tested to determine core-to-clad contact area.

2. Physics and Instruments

Criticality experiments performed with plutonium solutions in an unreflected 15.2 in. diam sphere yielded data on the effect of nitrate on criticality. Data for evaluating the effects on criticality of an air gap between the reactor core and its reflector were also obtained.

Measurements of reactor noise made on plutonium solution systems show qualitative agreements with theory that predicts subcriticality of a reactor can be determined independently of a knowledge of kinetic parameters such as the prompt neutron lifetime and delayed neutron fraction.

Fundamental data were obtained for determining the validity of pulsed neutron source experiments for large systems through experiments performed in an "infinite" water tank.

A difficult and important problem relating to the safety of processes involving dissolution of uranium rods moved a step nearer solution with successful application of a three-region lattice Monte Carlo code to uranium-water lattice data.

Nuclear safety problems in which neutron interactions between vessels must be studied can now be done more accurately and 15 times faster. An IBM interaction code has been revised in several ways to accomplish these goals.

One designed hybrid preamplifier was completed, tested, and delivered to N-Reactor for use with the neutron subcritical monitor. Performance was satisfactory; however, minor transient noise problems remain to be resolved.

Detailed calibration tests were initiated on the completed Pu^{239} liquid sample counting system developed for use at the 234-5 Building, CPD.

N-Reactor analog simulation studies continued to define steam generator controller setpoints maintaining satisfactory surge tank operation during a scram. Computer runs have been made; the data are being analyzed.

Analog computer programming for defining the xenon transients in a large reactor was essentially completed. Circuits were developed which permit reading-out the reactor node powers sequentially and displaying them as a profile on an oscilloscope.

The feasibility of modifying the N-Reactor fuel-end closure test to permit nondestructive measurement of end cap thickness is being investigated. Need for the added inspection is brought about by inaccuracies in the fuel machining process, which may reduce the end cap thickness beyond acceptable limits. Results are encouraging although it may be preferable to develop new equipment rather than modify existing testers.

A nondestructive test is being developed to insure that the cores of lithium aluminum fuel cores are not bonded to their aluminum jackets. Pulse echo tests are giving favorable results.

An alternate method of detecting unbonds on the ID of N-Reactor fuel elements has been successful in the laboratory. The testing technique involves

[redacted]

the outside-in technique of examining the ID interface similar to the method which has been successfully demonstrated on Al-Si fuel.

Ultrasonic tests are being used to detect cracks in N-Reactor fuel end caps by inspecting the bar stock from which the caps are machined, the as-machined end caps, and the caps on completed fuel elements. All approaches appear feasible.

Postirradiation testing of inner N-Reactor fuels was completed using the UT-10 station in 105-KE basin. No additional flaws were found. A summary of the findings from testing of all of the 144 irradiated fuels was written.

A MERCY computer program has shown the new Al-Si "outside-in" internal bond test to perform substantially better than the existing test.

A study of the characteristics of several possible operating methods of the triple-axis spectrometer was completed and measurements were resumed to determine the neutron scattering law for polystyrene.

The developmental spectrometer for slow-neutron inelastic scattering by time-of-flight was operated under test during the month. Experiments were performed to determine the operating characteristics of the system. A survey measurement was made of the angular distribution of scattering from vanadium.

The reactivity effects which arise from large plutonium oxide particles in mixed, uranium-plutonium fuel elements have been investigated. If the fuel becomes homogeneous under high power irradiation, a gain of 1.5% in k_{eff} may be expected.

The characteristics of the MTR when fueled with plutonium is being studied to determine whether such a high power core loading would be a suitable test of the Phoenix Fuel Concept. Comparisons of survey calculations with the 1958 plutonium loading are good.

Experiments in the PCTR to study the physics properties of Phoenix fuel cores have begun. The first set of measurements use U^{235} and polyethylene for calibration of subsequent plutonium experiments and to gain experience in fuel handling.

The first measurements of reactor temperature coefficients in the PRCF were successful. The reactor was loaded with EBWR mixed oxide fuel. The temperature of the water and fuel was changed from 20 to 72 C.

Estimates were made of the variation of alpha for Pu^{239} at the 0.3 ev resonance due to competition for neutrons by other isotopes.

Pu^{238} indifference prices were calculated for production via Am^{241} target irradiation.

Improvements were achieved in the curve fitting and plotting code, CURVES.

The Fuel Cycle Analysis Chained Computer Program Guide (HW-79951) was completed and is being cleared for off-site distribution.

Multiplier phototube comparison testing was completed regarding the PRTR fuel element rupture monitor. Performance with the present tubes can be improved using thermal insulation and lead-shield collimation.

One of two U^{234} neutron flux detecting regenerating ion chambers being fabricated offsite requires rebuilding by the vendor because of excessive flaking of the U^{234} coating.

One experimental B^{11} beta current neutron flux monitoring chamber was fabricated with 1 teraohm resistance between center wire and sheath.

Difficulties arose in tests at KW-Reactor on the microwave in-core neutron flux monitor. Although an expected change in attenuation was noted as the assembly was inserted in the reactor core, data (obtained by standing wave ratio and interferometer methods) were erratic. Temperature caused effects are suspected.

New oscillators and amplifiers are being built for the multiparameter tubing tester. Improvements were made in the rotating air core transformer. Preparations are being made to test 100-N exchanger tubing.

Shear-wave attenuation measurements with bonded shear transducers have not been successful. An oblique incidence, longitudinal-wave method has been devised. Further qualitative explanations of critical angle effects have become apparent.

Preliminary ultrasonic and eddy current fatigue test development continued. Fatigue in an aluminum Krouse fatigue specimen was detected ultrasonically. Copper, aluminum, and stainless steel fatigue sample preparations continued. An ultrasonic tank and manipulators are being fabricated.

Ultrasonic imaging using a light beam reflected off a water surface was demonstrated. The ultrasonic image of a wire screen inserted in an ultrasonic beam was converted to an optical image and photographed.

Pulse and steady state thermal wave transducers for nondestructive testing are being investigated. Theoretical studies of the parameters governing the sensitivity of the transducers are under way. Initial computations of signals from transducers under various conditions are being used to optimize transducer designs.

An infrared method for determining the power output of isotope heat sources is being investigated. Surface temperature measurements on a 2-1/2 in. long by 2-1/2 in. diam electrically heated dummy isotope source showed that the sensitivity of surface temperature to changes in power generation was approximately 1.5 C/watt.

Both ultrasonic and radiographic testing service was provided as required on prototype isotope containment cells. Design criteria were outlined for a mechanical system which inspects 100% of the containment cells. Several ultrasonic transducers for performing the inspection were also fabricated.

[redacted]

A method of generating ultrasonic waves by using the forces associated with the electric field present when a voltage is applied on a capacitor was also investigated. Although the system is not very sensitive, very broadband ultrasonic waves are generated and received without the necessity of an ultrasonic coupling medium.

Fabrication and installation of meteorological equipment in the L-19 aircraft have proceeded satisfactorily. A special instrument panel and recording camera have been found to be stable in flight. Additional vacuum systems have been installed for use on air samplers. The meteorologist-pilot has achieved the proficiency necessary for the experiments planned in diffusion, transport, and scavenging.

The whole body counting program in Alaska was completed for the summer. The average adult body burdens of Cs^{137} are significantly higher than observed during the summers of 1962 and 1963.

A technique that uses a 3 in. NaI crystal located at the groin and with the upper body bending over it has been demonstrated as a quick and inexpensive method needing only portable equipment for determining whole body burdens of Cs^{137}.

The Hanford mobile whole body counter was used to count a group of people who have a completely meat-free diet. Their unexpected above-average body burdens of Cs^{137} appear to be caused by large quantities of whole wheat bread in their diet. The whole wheat flour has two or three times as much Cs^{137} as normal white flour.

New dog masks were designed to improve performance of the smoke inhalation control system used for canine experiments at the Biology Inhalation Laboratory. The masks will force mouth breathing at all times.

Design was completed on a plutonium detection probe to be used for measurements of Pu^{239} in human wounds by detection of the 17 kev X-rays.

[redacted]

Directional dependence and gamma interference measurements were conducted with the experimental neutron dose rate detector, which uses a lithium-foil covered surface barrier diode and various size spherical polyethylene moderators.

The thyroid uptake (I^{131}) detection and signal transmission channel was completed for use in the Biology animal physiological function and radioisotope uptake radiotelemetry system.

Fast pulse generator and solid state amplifier circuits, with rise-times in the order of 1 nsec, were developed for use in investigating multiplier phototube single electron counting methods, which will be applied in dosimetry studies.

Five remote data stations were completed and are performing satisfactorily for use in the Atmospheric Physics radiotelemetry system. In addition, improvements were incorporated in the central station to secure greater reliability and comparison measurements.

A full-scale effort was required to assess the cause and magnitude of damage on the 16 dump condensers at N-Reactor. Analysis of three units by eddy current methods showed the tubes were worn, or fretted, by bands holding the u-bends together. Only the tubes on the outside of the bundle were affected; a visual examination was given the rest of the units.

Image intensification and magnification of gamma ray radiography is now approaching sensitivities achieved with film radiography. The system is all electronic.

Defects built into a tube before swaging a ceramic fuel element have been successfully resolved ultrasonically after fabrication of the element. This demonstrates the feasibility of production testing both vibratory compacted and swaged fuel elements.

A rotating transformer and eddy current coil assembly has been successfully completed for helically scanning process tubes. This method increases the sensitivity and locates the orientation of a defect.

3. Chemistry

A Columbia River travel time study was made using a "pulse" of I^{131} tracer introduced by reactor operations. Data were also obtained which will permit the use of Na^{24} as a tracer in the future.

Special 8.33 in. long N-Reactor fuel pieces were fabricated and charged to N-Reactor preparatory to additional tests of fuel integrity under thermal stressing.

Rates for dissolution of Mallinckrodt sol gel thoria in HNO_3-HF-$Al(NO_3)_3$ were found to be independent of aluminum concentration in the 0.1 to 0.2M range and not seriously reduced at 0.5M aluminum. They were also the same at 0.01 and 0.025M HF. There appears no advantage in using the higher HF concentration.

Further protactinium scavenging studies were performed in preparation for the forthcoming 6-ton Th-U^{233} test in the Purex plant. Since the results with acid deficient scavenging upon MnO_2 were poor, attention was turned to acidic conditions, and a suitable flowsheet was defined.

A fully successful macrolevel test of a compact-band chromatographic ion exchange process for the recovery and purification of Am^{241} has been completed. Americium recovery exceeded 96%.

Contrary to previous reports of a two-step reaction, it has now been concluded that the electroreduction of Pu(III) to metal in chloride salt melts occurs via a single step involving a three-electron change.

Ground water samples from a series of wells off the Northwest end of Gable Mountain swamp are reflecting the discharge of contaminated cooling water to the swamp from Purex in mid-June. No untenable ground-water contamination situation situation is expected to result from this incident.

Inundation of the lower 3.5 ft of the soil column beneath the Redox 216-S-1 and -2 cribs during the last 3 yr as a result of a local water table level increase has resulted in a 25 to 50-fold increase in the Sr^{90} concentration of the ground water at that location.

In a study of pressure buildup in the full-level strontium-loaded zeolite container, the equilibrium pressure caused by radiolysis was found to be quite low (about 4 psig).

Preliminary results with simulated process solutions show that cesium, recovered by ion exchange with zeolites from Purex alkaline supernatant waste, can be readily purified by alum crystallization. About 99.8% of the sodium was separated from the cesium by three crystallizations; a 90% cesium recovery was achieved.

Analysis of the technetium metal ingot showed the following impurity levels: < 2 ppm oxygen, < 0.006 ppm hydrogen, and < 3 ppm nitrogen. Analytical standards are being prepared from this material for distribution to all interested Hanford laboratories for calibration purposes.

A design for a new plutonium reclamation facility dissolver (Project 880), which provides for better thermal circulation, changing of acid and nitrogen entry points, and increased surge capacity was nearly completed this month.

An immersion-type photometer sensing unit has been constructed and tested successfully for use in estimating the U(IV) concentration in salt cycle chloride salt baths.

A 48 hr run of the 14 in. spray calciner coupled to a continuous melter was completed successfully. Simulated sulfate-free Purex waste with added colemanite was the feed.

A 7090 program has been written to process data obtained from the Waste Solidification Engineering Prototype using the automatic data logger.

In-cell installation of equipment for full-level testing of the Brookhaven continuous glass process was virtually complete at month's end. "Hot" operations will begin in September.

The bacteria count in Purex alkaline waste condensate samples at different times was determined. It was determined that the growth of bacteria in the condensate during storage can definitely complicate subsequent treatment.

Procurement steps for the Containment Systems Experiment pressure vessels continued. Research and development work related to fission product aspects of the program was initiated with installation and testing of a new 50 kw high frequency induction furnace generator.

Multidimensional coincidence spectrometry was used to measure Co^{60}, Ru^{106}, Ce^{144}, and Ra^{226} in the salts from 12 liters of ocean water and the level of several radionuclides in bass muscle from a fish caught in the Columbia River.

Sixteen hair samples from Alaskan Eskimos were found to contain Cs^{137} in concentrations ranging from 1 to 8 dis/min per gram of hair and 3 to 8 dis/min per gram of hair per microcurie of Cs^{137} body burden.

The cosmic ray-produced radionuclides S^{38} and Cl^{38} were measured for the first time in rainwater samples this month. Values obtained from five rain samples were 4-13 dis/min per liter for S^{38}, and 9 to 147 dis/min per liter for Cl^{38}.

The first measurements of compatibility of proposed promethium heat source forms with a variety of clads were completed. Of the cladding materials tried, tantalum and titanium appeared most promising for use with promethium metal.

4. Biology

Water temperature seems to markedly affect the uptake of zinc into fish. These rather unexpected results are preliminary.

[redacted]

The first pig fed 25 μc Sr^{90}/day was killed. She had received the regimen for 3-3/4 yr and now showed blood dyscrasia, tentatively diagnosed as myelogenous leukemia. Dose to bone marrow was about 3000 rads.

Higher concentrations of Cs^{137} in the rumen of sheep than in their diet are being observed, essentially confirming results noted in Alaskan caribou.

Desferrioxamine-B given to rats with DTPA was better for removing well-deposited Pu^{238} than either agent alone.

A radiomimetic chemical was found more effective than X-radiation in inhibiting bile salt absorption in the GI tract of rats.

Adsorption, as contrasted to metabolic uptake, appears to be the dominant mode of radionuclide deposition in plankton from analyses of radionuclide content of plankton and environmental conditions in the river.

A maximum Cs^{137} body burden of 3000 nc was found in a nonnative resident of a river village near Kotzebue, Alaska. The man habitually eats much more caribou than most natives.

5. Programming

Programming Operation has been merged with Physics and Instruments Laboratory and Radiation Protection Operation. These groups are now reporting fuel cycle analysis and nuclear health and safety work, respectively.

TECHNICAL AND OTHER SERVICES

Intravenous administration of DTPA to increase the amount of plutonium excreted are continuing on the Hanford Laboratories technician who received the plutonium contaminated injury on July 10 while working at the Plutonium Metallurgy Building (231-Z). Additionally, and for the same purpose, intramuscular injections of Desferol are being given along with DTPA. No increase in the amount of plutonium excreted has been noted.

Efforts to eliminate the radiation problems associated with the cooling water swamps for Purex continued through August. All highly contaminated areas of the "B" Swamp have been backfilled and this swamp is again in good condition. Efforts are continuing to raise the water level in the Gable Mountain Swamp with the application of Bentonite clay. Although the concentration of radioactive materials in the water is now satisfactory, the depth of water over contaminated bottom is not sufficient.

Several run-to-rupture tests were designed comparing the AlSi and HDS processes for uranium of different enrichments.

A study was completed of the reliability of a zone temperature monitoring system.

Analysis of preliminary data from two production tests was completed. Each test compared six canning treatments for 22 different dimensional statistics.

Programs were completed that compute three rather complicated mathematical functions that frequently arise in soil physics investigations.

A document was issued that explains and illustrates the computer program for producing magnetic tapes to control the prototype Sheffield rotary contour gage.

Documentation was completed of the computer program that unfolds an observed two-dimensional particle sized distribution into its three-dimensional counterpart.

A new and expanded version of the GEM program ran successfully.

An analysis was completed of data describing swimming performance of Zn^{65} treated trout.

[redacted]

SUPPORTING FUNCTIONS

PRTR output for August was 580 Mwd for an experimental time efficiency of 47% and a plant efficienty of 27%. There were eight operating periods during the month, three of which were terminated manually and five were terminated by scrams. A summary of the fuel irradiation program as of August 31, 1964, follows:

	Al-Pu		UO_2		PuO_2-UO_2		Other		Program Totals	
	No.	Mwd	No.	Mwd	No.	Mwd	No.	Mwd	No.	Mwd
In-Core	0		8	1 850.5	77	11 945.9			85	13 796.4
Maximum				322.4		336.7				
Average				231.3		155.1				
In Basin	7	572.5	25	2 564.1	47	5 334.5			79	8 471.1
Buried							1	7.3	1	7.3
Chemical Processing	68	5 465.8	35	1 965.8					103	7 431.6
Program Totals	75	6 038.3	68	6 380.4	124	17 280.4	1	7.3	268	29 706.4

Note: (Mwd/Element) x 20 ≃ Mwd/ton_U for UO_2 and PuO_2-UO_2.

Heavy water loss and indicated helium loss for the month were 923 lb and 149, 129 scf, respectively.

A total reactor outage of 184 hr was charged to repair work. Main items were:

Vibration check and repair of primary pumps
Jumper repair
Helium compressor repair
Tube to nozzle regasketing
Rupture Loop repairs

A standard size UO_2 PRTR fuel element was intentionally defected with a saw cut estimated to be about 1.5 in. in length. This element was used as the test element for Fuel Element Rupture Test Facility (FERTF) Test No. 7. During August, the element was subjected to seven critical

periods. Visual examination subsequently in the storage basin revealed no apparent evidence of defect propagation or of a significant release of fuel material.

Total Technical Shops Operation productive time for the period was 19,015 hr. Distribution of time was as follows:

	Man Hours	% of Total
N-Reactor Department	1 911	10.0
Irradiation Processing Department	3 122	16.5
Chemical Processing Department	159	0.8
Hanford Laboratories	13 823	72.7

Total productive time in Laboratory Maintenance Operation was 17,500 hr of 20,600 potentially available. Of the total productive time, 93% was expended in support of Hanford Laboratories components, with the remaining 7% directed toward providing service for other HAPO organizations. Manpower utilization (in hours) for August was as follows:

A. Shop Work		1700
B. Maintenance		7200
1. Preventive Maintenance	2200	
2. Emergency or Unscheduled Maintenance	2000	
3. Normal Scheduled Maintenance	3000	
C. R&D Assistance		8600

The heavy water inventory at the end of August 1964 showed a loss of 923 lb valued at $12,764 for the PRTR. Heavy water scrap generated during the month amounted to 5963 lb, resulting in a $7470 charge to operating costs. Total scrap on hand at August 31, 1964 amounted to 10,539 lb valued at $130,385.

Cumulative data of Hanford visitations:

	Number of Visitors	
	In August	Since June 13, 1962
Visitors Center	3222	78 095
Plant Tours	102	---

[redacted]

HAPO professional recruiting activity for August:

	Plant Visits	Offers Extended	Offers Accepted	Offers Rejected	Offers Open
Ph.D.	1	7	1	1	9
BS/MS (Direct Placement)	0	0	0	0	0
BS/MS (Program)	0	0	0	0	1

Four Technical Graduates were placed on permanent assignments. Four new members were added to the roll and two terminated. Current program numbers 42.

Authorized funds for 12 active projects total $10,596,500. Total estimated cost of these projects is $11,793,000. Expenditures through June 30. 1964 were $4,165,000.

R S Paul

Acting Manager, Hanford Laboratories

HM Parker:JEB:dh

[redacted]

REACTOR AND FUELS LABORATORY MONTHLY REPORT

AUGUST 1964

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 02 PROGRAM

1. Metallic Fuel Development

Comparative Swelling of Uranium Alloy Fuels. A test of eight KSE-5 fuel elements was discharged from KER-1 after attaining a tube average exposure of about 2500 Mwd/ton. The test was similar to a previously discharged KER-2 charge operated to 1400 Mwd/ton and consisted of fuel elements containing uranium with low iron and silicon additions (N-fuel composition) and fuel elements containing uranium with 400 ppm iron and 800 ppm aluminum. Fuel swelling data obtained from pre- and post-irradiation bulk density measurements show consistently less swelling in the fuel with the iron and aluminum additions. The peak fuel swelling of the iron-aluminum containing fuel was 1.2 vol% compared with the peak swelling of iron-silicon containing fuel at 2.2 vol%. Similar swelling behavior was observed in the 1400 Mwd/ton exposure test.

Fluted Fuel Element Irradiation. A failure occurred in one of two N-single tube fuel elements with fluted outer surfaces which were being irradiated in the ETR M-3 pressurized loop. The failure occurred during the 13th cycle of reactor operation for this test after the element had received an accumulated exposure of approximately 2500 Mwd/ton. About 35 grams of uranium were lost from the failed element. Damage was confined to one end of the element where, in addition to swelling from uranium corrosion product build-up, there was a longitudinal split in the cladding at the bottom of one flute and a circumferential tear at the base of the cap. A cursory examination of the element indicated that the longitudinal cladding split was in the vicinity of a marker tab which was spot-welded on the surface. This implicates the spot weld area as a possible point of initiation of the failure. Another possible location for the failure origin exists at the base of the cap where the bending stress in the cladding is expected to be at a maximum.

N-Reactor Fuel Fouling Detector. Four fuel fouling detectors (crud probes) fueled with thorium-uranium alloy have been charged into N-Reactor under Production Test NR-14, N-Reactor Department. The decision to make this test was a result of three successful prototype

irradiations of 400 Mwd/ton, 1000 Mwd/ton, and 1750 Mwd/ton. No defects due to irradiation deficiencies were observed on any of the three test elements during radiometallurgical examination, and no measurable dimensional changes occurred. A report on the development and testing of this thermocoupled test element is in preparation.

Alternate Uranium Compositions. Studies are in progress to evaluate uranium base alloys in terms of fuel fabrication history, corrosion behavior, and irradiation performance.

Twenty-seven rods of 11 different alloy compositions were co-extruded with Zr-2 cladding. The rods are now being evaluated for cladding thickness, uniformity, and bond quality. All 17 of the alloys planned for irradiation in NaK capsules have been fabricated into Zr-2 clad rods from which test specimens are being prepared.

Fabrication of Target Elements for NR-8. Final delivery of all target elements for production test NR-8 was made to N-Department on July 31, 1964. This delivery included 650 full length elements and 135 short target elements, culminating 2-1/2 months of intensive effort in the fabrication of elements for a feasibility study of a coproducer loading for N-Reactor. These target elements consist of a lithium-aluminum alloy core clad with a coextruded aluminum jacket, as a tritium diffusion barrier, closed with welded aluminum end caps. This assembly is, in turn, sealed into a Zircaloy can with welded end caps. All of the inspection data from the target elements has been placed on punched cards to facilitate sorting and calculation and to provide a means of data retrieval or input into other fuel elements calculation programs such as TUM. A final report is being prepared.

Fuel Measurements. Measurements have been completed on 108 driver tubes for N-Reactor production test NR-8. These elements received warp, wall thickness, length, and density measurements which can be compared directly with similar post-irradiation measurements. Nine elements were measured for end cap profile.

Coextrusion of Aluminum Clad Target Material. Coextrusion billets containing 1-1/2% Li-Al cores are being prepared for further target extrusion studies. It is desired to find the maximum reduction ratio that will produce an unbonded core-clad interface which may be encountered during the high reductions in the production extrusion of N-target material. The unbond acts as a diffusion barrier to tritium. Bonding can be prevented at high reductions by coating the billet cores with a water-aquadag mixture. However, it is

doubtful that all the water is removed when the aquadag dries, thus leaving some hydrogen which will contaminate the tritium produced.

A dry parting agent will be placed at the interface of the billets in an attempt to prevent bonding. Fine flaked graphite and fine Al_2O_3 powder will be tried initially as the parting agents. The exterior of the core and the interior of the aluminum can will be dry blasted to provide small pockets for holding the powder.

Target Element Development. As part of a program for the evaluation of the irradiation performance of alternate target materials, samples of $LiAlO_2$ and Li_2SiO_3 were irradiated in KER Loop 2 as aluminum cermets, mixtures of the two powders, and as separate powder samples. A 14 wt% Li-Mg alloy was also included in this test.

From irradiation history data, the gas contents of the test samples (GVR) are calculated to be as follows:

$LiAlO_2$	- aluminum cermet	-	3.1 - 4.2
$LiSiO_2$	- aluminum cermet	-	5.6 - 7.0
$LiAlO_2$	- 7.9		
Li_2SiO_3	- 12.9		
$LiAlO_2 + Li_2SiO_3$	- 10.7		
Mg - 14 wt% Li	- 7.6.		

Visual examination of the Zr-2 canned elements in Radiometallurgy shows no evidence of irradiation-induced changes. Analysis of the gas inside the aluminum cans and an examination of the ceramic cores themselves is planned.

Testing of intentionally defected Li-Al alloy cores doubly canned in Zr-2 and aluminum has been completed in a hot water out-of-reactor loop. After 297 hours in 280 C water, none of the samples with defects through the Zr only showed indications of diameter changes or significant corrosion of the aluminum can underneath. On those samples with defects through both the Zr-2 and aluminum cans diameter increases were observed after four hours. Bulging and splitting of the Zr-2 and aluminum cans and continued corrosion of the Li-Al core resulted with further exposure. The maximum bulged-diameter observed before splitting of the Zr-2 can was approximately 0.75 inch (nominal as fabricated diameter was 0.560 inch). The sample cans after splitting are severely distorted, but coolant flow was not significantly affected.

High Melting Temperature Lithium Alloys. According to the bismuth-lithium phase diagram, the intermetallic compound Li_3Bi (91 wt% Bi + 9 wt% Li) has a melting point of 1145 C. This alloy appears to be a possible candidate for the high melting temperature lithium alloys for target element cores. A small ingot of this alloy was made and examined. The alloy was brittle, oxidized readily and indicated a positive thermal coefficient of expansion. Metallography was impossible because of extremely reactive nature of the metal.

Target Elements for PCTR. A load of target elements containing natural lithium fluoride is being fabricated for the Physical Constants Test Reactor. Lithium Fluoride is being used in order to obtain precise control over the amount of Li-6 in the elements.

The lithium fluoride core will consist of LiF pellets containing 2 wt% sodium stearate as a binder and pressed at 60 ksi. Pelletizing and sintering studies established the need for the binder, and since uniform pellets with good green strength were obtainable without sintering, unsintered pellets will be used for all elements. Very precise control over time, temperature, heating, and cooling rates were necessary to obtain the required uniformity of density and dimensions in the sintered pellets.

The pellets will be sealed into aluminum tubes and the aluminum tubes sealed into Zircaloy-2 tubes using welded closures.

The fabrication of the elements is in its final phase of production, with the full load scheduled for delivery on September 4, 1964.

Hot Headed Fuel Element. Four hot headed, projection welded and brazed elements were beta heat treated and autoclaved in 400 C steam for 60 hours. Visual examination revealed that a uniform lustrous black film was formed.

An attempt to weld caps with six-ring projections appeared to be satisfactory. Metallographic examination of the cross section revealed that a fully welded and bonded joint was formed. Measurements indicate that approximately 65% of the cross section consists of projection welds, 14% consists of Zircaloy to Zircaloy bonds and 21% consists of uranium to Zircaloy bonds. These figures may be compared to cross sections of four-ring projection welds which consist of approximately 46% projection welds, 37% Zircaloy to Zircaloy bonds, and 17% uranium to Zircaloy bonds.

Nine-welded elements were tested in tension. The average tensile stress developed for four-ring projection welds which had been postheated sufficiently to effect brazing at the interface between projections was 25,600 psi. The average tensile stress developed for four-ring projection welds with only sufficient postheat to effect partial brazing was 21,600 psi. One element with six-ring projections and with no postheat developed a tensile stress of 32,600 psi.

Metallic Fuel Welding. An improved end closure for NPR elements using resistance projection welds and a hot formed element (hot headed projection welded) is being developed. Welding of outer fuel pieces has been done on the 1200 KVA welder at the U.S. Army Rocky Mountain Arsenal in Denver. Twelve pieces were autoclaved, resulting in a general failure of all elements. It appears that failure of one element may have initiated failure in the others.

N Outer Tube II Fuel Support. Attempts to cold form NOT II fuel supports in the 119-ton crank press were unsuccessful and resulted in cracked supports and broken die inserts. The die was then modified for hot forming using a 2.5 KVA resistance welder as a heat source. The welder is just marginal in capacity and will not heat the wire above 640 C for forming. Die quenching appears to be an important part of the forming cycle for mechanical stripping purposes, thus the crank press control has been modified to provide this step in the forming cycle. Forming the parts in the crank press should provide better dimensional stability than was noted for parts formed in the 600 KVA welder.

Fabrication of Zircaloy Support Material. Increased stiffness in rolling Zircaloy strip has been observed on several occasions when a period of weeks has elapsed in the fabrication schedule, indicating a possible aging process. Tensile specimens were prepared from material partially through the fabrication schedule for determination of room and elevated temperature aging. Tensile properties after one, five, and 20 hours at 200, 300, and 400 C and 72 hours at 400 C in steam have shown a maximum increase in yield strength of about 6000 psi. Tests made at weekly intervals up to seven weeks have shown increases in yield and ultimate strengths of about 3000 psi due to room temperature aging. These changes do not appear sufficient to cause the apparent increase in rolling force observed.

Resistance Heated Tube Furnace. The Be-Zr extrusions, destined to become wire for use in experimental N-fuel closures, have been hot swaged to the point where they no longer fit into existing furnaces. A ten-foot-long, one-inch diameter, resistance furnace has been made

which will be heated by the 75 KW Reslec Power Supply. It is designed for feed-through operation so that a continuous hot swaging operation may be made on long lengths of rods and tubing.

Behavior of Li-Al Alloy in 280 C pH 10 Water. Twelve defected Li-Al alloy target elements with Zr-2 outer cladding and C-64 F aluminum inner cladding have been tested in TF-9 at 280 C and pH 10 for 209 hours. Two of the rods with slitted defects to the core began swelling after four hours of exposure, and after 40 hours, the diameter had increased to 1.0" from an original 0.56". After 209 hours, 90% of the core had been oxidized and washed out. Two other rods with pinhole defects through the end cap to the core showed swelling after 16-24 hours, and one of the rods split open after 100 hours. The rods that had pinholes or slits through the Zr-2 to the depth of the outer aluminum cladding did not undergo any appreciable swelling.

2. Corrosion and Water Quality Studies

Corrosion of Copper Alloys by Ammonia. N-Reactor is considering the use of ammonium hydroxide for pH and oxygen control in the graphite cooling system. The flow sensing lines in this system are constructed of copper tubing and brass fittings. Tests have been completed to determine if these components are susceptible to ammonium stress corrosion cracking. No cracking was found on copper tubing or brass fittings exposed to stagnant pH 9-10 ammoniated water or its vapors for two months at 110 C, two months at 150 C, and one-half month at 55 C.

Stressed samples of seven copper base alloys have been placed in the air atmospheres near piping components in the N-Reactor primary system.

Several ASTM B147 manganese bronze samples (this material is used in some valves in the primary system) stressed to 110% of yield have cracked due to ammonia vapors leaking from the primary system. None of the ASTM B147 samples stressed at yield stress or below, and none of the other alloys at any stress level have cracked. Control samples of ASTM B147 stressed at 110% of yield have not cracked in other atmospheres.

Corrosion of N-Reactor Steam Generator Tubing. Sections of N-Reactor steam generator tubing containing intergranular corrosion attack experienced enough corrosion to cause the grains to fall out when exposed to eight decontamination cycles with a proprietary sulfamic acid solution. No significant increase in corrosion was

observed when a proprietary bisulfate solution was used for eight cycles.

N-Reactor Shutdown Radiation Measurements. Monitoring sites for N-Reactor shutdown radiation measurements were located, marked, and numbered. The first survey on August 6, 1964, showed the radiation levels to be quite low; generally, they were less than 1 mr/hr.

Crud Deposition on N-Reactor Fuel Elements. Analytical results were obtained on the crud film removed from the ruptured fuel element from N-Reactor. The total deposition on the element was 13.5 mg/dm^2 with a corresponding thickness of about 0.04 mil. An increase of surface temperature of less than 1 C would result from this film at a heat flux of 500,000 $Btu/hr\text{-}ft^2$. X-ray diffraction analysis of the crud produced a pattern which is different than any forms of FeO, Fe_2O_3, $Fe_2O_3 \cdot H_2O$, FeO·OH, and FeO(OH).

KER-1 Testing of NH_4OH. The testing of hydrogen gas addition to KER-1 ammoniated coolant was completed. During the test the average residual hydrogen concentration was maintained at 25 cm^3/kg (STP) to determine the effect on the crud films formed on the fuel elements. A cursory examination of the fuel elements discharged from the loop indicated uniform reddish deposits on the upstream elements while the downstream elements appeared virtually free of film. It thus appears that maintaining the higher hydrogen concentration may have some beneficial effect in reducing crud deposition, particularly on the downstream elements.

The addition of the hydrogen reduced the NH_4OH decomposition rate from 0.05 lb/day to 0.02 lb/day during normal operating conditions.

Ex-Reactor Evaluation of Nickel-Plated Aluminum. Three aluminum alloys -- 8001, 1245 and 1.8 wt% Fe, 1.2 wt% Ni in high purity aluminum -- have been nickel-plated by electrolytic and chemical deposition. Plate thicknesses were nominally 1.0, 0.6 and 0.3 mil, although preliminary metallography indicates the electrolytic plate to be thinner than anticipated. Plated coupons were heat treated at 400 C (752 F) for 2.5, 10 and 40 hours, and at 450 and 500 C (842 and 932 F) for 2-1/4 hours.

In autoclave exposures at 330 C (626 F) for 3 days and 10 days (total) all of the electroplated 1245 alloys failed catastrophically; failure had begun on two chemical plated 1245 alloy coupons which were heat treated at 500 C. The chemical plate on the 1.8 wt% Fe, 1.2 wt% Ni alloy spalled following heat treatment. Otherwise, the chemical plate behaved well in autoclave exposures to 10 days. On

the basis of the autoclave tests, elements to be exposed in-reactor will be plated by chemical deposition; plate thickness and heat treatment are to be determined by further autoclaving and by electrolytic cell tests.

3. Gas Atmosphere Studies

In-Reactor Corrosion and Hydriding in Simulated Reactor Gas Atmosphere. Coupons of Zircaloy-2 and 4 were exposed in-reactor for 58 days at 400 C (752 F) in a helium atmosphere contaminated with CO, H_2, and sufficient H_2O vapor to maintain an oxide film. An identical control capsule was run out of reactor at the same conditions. Weight gain data show no irradiation-induced acceleration of corrosion in contrast to the 1962 capsule, which showed a factor of 2 to 3 higher weight gains in-reactor. Additional thermocouples installed to check gamma heating effects showed the Zircaloy samples to be 30-40 C (86-104 F) hotter than the gas. This indicates that the 1962 capsule operated hotter than measured since the thermocouples monitored only gas phase. A temperature rise of 35 C (95 F) is just the amount necessary to produce the factor of 3 corrosion increase observed in the first capsule. The in-reactor hydriding rates were normal (30-40% pickup rate) and consistent with the 1962 capsule results.

A "thick film effect" was noted for samples having a 50 mg/dm^2 pre-film at the start of the test. Both in-reactor and out-of-reactor thick film samples showed reduced corrosion rate and accelerated hydriding rates (70-80% pickup rates).

Graphite-Water Vapor Reaction. The effect of hydrogen on the water vapor-graphite reaction is being studied. A sample of TSX graphite was pre-oxidized to approximately 5% burnoff in air and then oxidized by water vapor and water vapor-hydrogen mixtures. With water-vapor at 4.0 mm Hg vapor pressure, 1.9 mm of hydrogen reduced the oxidation rate at 780, 800, and 850 C by factors of 3.5, 3.6, and 3.8, respectively. Preliminary results with 6.8 mm hydrogen present indicate a further two-fold reduction in oxidation rate.

Thermal Oxidation of Large Graphite Samples by Water Vapor. Because of the sensitivity of oxidation rate to the degree of oxidation of the graphite, provision has been made to follow the rate of oxidation instantaneously by continuously analyzing the effluent gaseous products from the reaction. In an initial test of the new equipment, a 263-gram sample of TSX graphite was exposed at 842 C

for 55 hours to about 6000 ppm of water vapor in helium. The concentration of carbon monoxide in the effluent after 5.28 and 52 hours, respectively, was about 49, 86, and 92 ppm; hydrogen was 52, 92, and 100 ppm. These results show a large variation in rate in the initial stage during which only 0.09 wt% of the graphite was oxidized. Good agreement was found between measured weight loss and weight loss calculated from gas composition and flow rates.

The nonequivalence of the carbon monoxide and water vapor concentration arises from the partial conversion of CO to CO_2 by reaction with water vapor -- the water-gas shift reaction. The carbon dioxide concentration was determined experimentally in two instances and was found to confirm the stoichiometric equivalence

$$C_{CO_2} = \frac{C_{H_2} - C_{CO}}{2} .$$

The results show that reasonably accurate oxidation rates can be expected using continuous gas analysis to monitor the reaction.

4. Process Tube Development

Fracture Studies. The first stress rupture test of a section of an irradiated KER pressure tube has been completed. It ruptured in 492 hours at 300 C (572 F) and at a hoop stress of 61,000 psi. A similar specimen in the unirradiated condition would have been expected to fail at the same stress in 20 hours. Stated another way, survival of an unirradiated tube for 492 hours would require a 3000 psi lower stress.

5. Thermal Hydraulics Studies

Transient Heat-Transfer Experiments for N-Reactor. Two experiments were conducted to determine fuel temperatures following the rupture of the line supplying an N-Reactor inlet riser. These experiments were conducted in the heat transfer laboratory using an electrically heated full-scale model of one-half of an N-Reactor fuel column with typical inlet and outlet connectors and fittings.

The experiments were designed to simulate the rupture occurring just upstream of a check valve in a reactor riser. In such a case, the check valve would prevent back flow from the affected tubes and, because of the rupture, there would be no supply of water for flow in the normal direction. It would be expected that boiling would

quickly expel the coolant from the process tubes, but as the pressure decreased, flashing of water in the inlet connectors and risers would provide some steam flow past the fuel. The question is whether the fuel elements would receive sufficient cooling to prevent melting for such a situation.

In the experiments, typical in-reactor steady-state operating conditions (inlet temperature, flow rate, pressure, and specific power) were reached with recirculating flow through the experimental section. The transients were initiated by operating quick-acting valves to isolate the experimental section from the normal high pressure loop piping and to allow blowdown of water from the experimental section. During the transient, power was reduced according to a 30 mk scram curve, with a 1.1 second delay for safety circuit actuation and rod drop times. Pressures, coolant temperatures, and fuel model temperatures at several locations were recorded continuously throughout the transients, each of which was continued for about 35 seconds.

Behavior at fuel model powers of 2200 and 2500 kw was investigated in the two experiments. Maximum fuel model temperatures reached values of only 1000 to 1100 F in both cases, but further analysis of the data is necessary to determine if melting would occur in the reactor for such an event.

Water Boil-Out Times for the Present Production Reactors. Calculations were completed to determine the time required to boil the water out of a tube containing thoria elements if the water supply to the tube was accidentally stopped. The calculations show that in case of such an accident 30 hours after a reactor shutdown, a process tube containing thoria fuel elements which had been operating at 150 kw would start to boil in about 46 minutes and would boil dry in an additional 96 minutes. For the case where the water stoppage occurred 80 hours after a reactor shutdown, boiling would start 61 minutes after coolant stoppage and the tube would boil dry in an additional 128 minutes.

Hydraulic Tests for the Present Production Reactors. Tests performed in the hydraulics laboratory for K-Reactor indicate that downstream flow plugging occurring from broken splines lodging in nozzle outlet ports can be reduced by preventing the movement of the broken spline into the nozzle port area by the use of a modified Van Stone seal. Flow plugging and reactor scrams will normally not be encountered if the nozzle port is protected with the perforated cages that are in use in the majority of the K rear nozzles. However, for those nozzles which have not been modified to accept the

cage, the Van Stone seal should be a satisfactory temporary substitute for preventing spline entry into the nozzle port.

Flow tests were run to determine the consequences of accidentally placing tubular elements (rather than perfs) of a downstream support charge in the rear nozzles of K and C-Reactor process tubes. The results show that the placement of a single tubular element in a K nozzle will not appreciably affect the flow characteristics of the process tube. If the nozzle outlet port is effectively blocked with an additional tubular element, flow decreases of 1 to 2% are probable. The resulting flow decrease for a C tube will be approximately 3% for a single tubular element in the nozzle since in this case the tubular element extends upstream of the nozzle port by 4-1/2 inches.

The operating characteristics of several orifice and venturi assemblies have been determined for B, D, C, and K Reactors with thorium target loadings. It was determined that these reactors (ribbed tubes) can operate satisfactorily with orifices which are readily available and which give supply characteristics that are compatible with the predicted thorium demand curves. A prototypical loading has been recently received, and final arrangements have been made for flow testing the 1.48-inch OD loads in the B, D, C, and K ribbed tubes.

Modifications of venturi cages have been made in the past by reaming undersize venturi holders and placing appropriately sized venturi inserts in the reamed cage. The inserts have been sealed to prevent flow through the Panellit tap cavity by placing O-rings in machined grooves around the periphery of the upstream and downstream portion of the 0.385-inch ID venturi insert. After installation of one of the modified inserts on a C-Reactor tube, a scram was experienced. Since no other modification was made, it was assumed that failure of an O-ring may have been the cause.

By testing in the hydraulics laboratory, it was determined that a severely cut or damaged downstream O-ring could cause a Panellit trip provided the Panellit setting was within 20 psi of the low or high trip set-point. Failure of the downstream O-ring permits back-flow between the venturi insert and the cage body and then into the main flow stream through the venturi throat pressure-tap holes. The result is an erroneous Panellit reading and a 3% flow reduction due to the increased turbulence in the venturi throat.

[redacted] [redacted]

If a damaged O-ring seats during a flow increase or after operating flow has been established, a Panellit decrease of approximately 20 psi and a flow increase of 3% will result. Conversely, if the downstream O-ring fails, a 3% decrease in flow and 20 psi Panellit pressure increase will occur. Failure of the upstream O-ring has little effect on Panellit response and flow in the C venturi cage since the mating upstream shoulders of cage and insert effectively prohibits flow through the cage from the upstream end.

6. Shielding Studies

N-Reactor Shield Evaluation. Experimental work in the top shield of the N-Reactor was completed on August 7. All gold foils from Test No. 8 were counted, thermal and resonance neutron fluxes calculated, and about one-third of the P-32 analyses and fast flux calculations have been completed. All gamma ray data have been analyzed and plotted. Analysis of shield temperature has begun. Analysis of data from the N-1 and N-2 tests has been completed.

Two MAC calculations were prepared and run to fit the experimental conditions and results. A third has been prepared, but not yet run, which closely approximates tests 5 and 6 where the reflector data were obtained. Results are considered to be in good agreement with the experiments to date.

7. Graphite Studies

N-Reactor Graphite Irradiations. The series of long-term irradiations of N-Reactor graphite is proceeding satisfactorily in the GETR. The two fourth-generation capsules, H-5-4 and H-6-4, have both successfully completed another cycle of irradiation, the fourth and first cycles, respectively. The first of the fifth-generation capsules, H-4-5, is in the final phase of construction. Several changes in sample location have been made in this capsule to obtain contraction data on samples previously irradiated at different temperatures. Four samples previously irradiated at 600 C will be continued at 800 C, six samples at 800 C will be continued at 600 C, and one formerly at 800 C will be run at 475 C. At least one of the 600 C samples, formerly irradiated at 800 C, will be cycled between 600 C and 800 C in subsequent capsules.

The changes in sample irradiation temperature will provide data of particular use to reactor operators since there may be some benefits from variation of reactor operating conditions.

B. WEAPONS - 03 PROGRAM

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

C. REACTOR DEVELOPMENT - 04 PROGRAM

1. Plutonium Recycle Program

Fuels Development

PRTR Fuel Fabrication. Three fuel elements were delivered to the PRTR including one special corrosion test element. FE-5253 has one rod composed of Zircaloy corrosion coupons and 18 regular Vipac fuel rods. This element is scheduled for full life operation and is counted as a regular production element. One extra fuel element is assembled and available for storage.

A short core fuel element was prepared using UO_2-filled rods assembled into a 19-rod cluster. The element will be exposed in the EDEL-1 loop to evaluate possible fretting behavior in a PRTR environment.

Two concepts are being pursued to fabricate 40-mil plutonium alloy wire for enrichment of uranium oxide pellet-filled rods. These wires would be inserted into cored UO_2 pellets. One concept is extrusion of a cast-billet, and the other is swaging the billet to size. Previous experience with extrusion has been partially successful for short lengths of wire, but eight-foot lengths must be fabricated.

A new swage rod loading hood was put into service which permits a time saving of approximately two manhours in the fabrication of a 19-rod cluster element. Improvements in the hood include: a short beam for the vibrator which allows two rods to be loaded at a time, and vented loading funnels through which the powders flow at much higher rates. Rods can now be loaded at a rate of about 20 per hour. Several safety features to decrease the probability of accidental contamination spread were also included.

Pneumatic Impaction of UO2. Excess oxygen in nonstoichiometric UO_2, introduced both by roasting and by adding U_3O_8, was found to

equilibrate among the various UO_2 particle size fractions upon heating under vacuum at 1200 C for 80 minutes in a double Nupac can. These results indicate that O/U ratios of Nupac fuel mixtures may be adjusted accurately to the desired levels simply by blending a calculated amount of U_3O_8 with the UO_2 or UO_2-PuO_2, in place of the less controllable roasting method currently in use.

Particle size distributions and O/U ratios of UO_2 prepared from pulverized, sintered UO_2 scrap by roasting for 16 hours at 125 C or by adding -325 mesh U_3O_8 mixtures before and after heating are shown in the following table.

Oxygen Distribution in UO_2 Mixtures
Before and After Heating in Vacuum to 1200 C

Particle Size Fraction, Tyler Screen Size	Roasted UO_2			U_3O_8 Added		
	Before Heating		After Heating	Before Heating		After Heating
	wt%	O/U	O/U	wt%	O/U	O/U
+ 35	3.2	2.002	2.008	3.9	2.002	2.024
- 35+ 65	26.8	2.004	2.011	23.8	2.002	2.027
- 65+150	28.1	2.005	2.008	26.9	2.003	2.026
-150+250	19.5	2.011	2.010	21.3	2.004	2.026
-250	22.4	2.036	2.012	24.1	2.153	2.025

PRTR Fuel Element Performance. Examination after 106 hours of operation in the PRTR rupture loop revealed no fuel washout or changes in appearance of an intentionally defected, pre-irradiated (2440 Mwd/ton), swage-compacted UO_2 fuel element. The maximum burst activity from the defect (1-3/4 inch long slit, 0.020 to 0.040 inch wide) was not sufficient to interrupt reactor operation. Expected bursts were observed during major power increases, loop heating, and loop depressurizations. The element has been subjected to seven critical periods, two manual shutdowns, and five scrams during its 106 hours in the reactor.

In-Reactor Clad Hydriding. A failure in the modified end cap region of PRTR rods containing contaminated fuel material substantiates that end cap crevices were not the cause of previous fuel element failures. A vibrationally-compacted PRTR element (FE-5233) containing impacted UO_2-1 wt% PuO_2 fuel failed after a burnup of 1800 Mwd/ton. This element differed from the standard vipac fuel design in that swageable type end caps which eliminate the crevice were being tested. Failure occurred in the bottom end cap region and was characteristics of previous failures caused by contaminated fuel material.

Laboratory Hydriding of PRTR Fuel Cladding. Three Zircaloy-2 test capsules were hydrided at 410 C for varying periods of time. Dry hydrogen flow was through the capsule while the capsule exterior was maintained in an argon atmosphere. Severe hydriding occurred in the end cap regions in two of the test capsules after 15- and 16-hour soaks at temperature. The third capsule, a special test capsule which had been partially reamed near the center to provide a fresh machined surface, failed at the ream after a 6-hour soak at temperature. Thus, machining appears to accelerate the hydriding.

Evaluation of Internal Iodine Attack on Zircaloy. Autoclaving of a full length fuel rod with a swaged UO_2 core contaminated with 165 mg of I_2 has not failed after two weeks at 400 C. The reaction layer on Zircaloy-2 capsules previously exposed to iodine at 400 C has been identified as alpha-zirconium.

A fuel rod has been prepared for the in-reactor phase of these tests with "quick-disconnect" end caps to permit easy underwater loading.

Inverted Cluster Fuel Element. The full length, Mark IX-B UO_2 inverted cluster (water tube) fuel element was successfully irradiated in the PRTR rupture loop and displayed no visually detectable dimensional changes or surface fouling. It operated at an estimated tube power of 720 kw (137 kw/ft maximum) at a reactor power of 70 mw and an average burnup of 150 Mwd/ton. Preliminary examination of the fuel cross section in the highest power generation region of the element indicates that maximum fuel temperatures were somewhat lower than the predicted 2200 C. The examination also revealed that the positioning of the internal water tubes was excellent at this cross section.

Irradiation Testing of EBWR Prototypic Fuel Rods. Capsule tests of EBWR UO_2-PuO_2 rods are performing satisfactorily under proposed 42 Mw EBWR conditions (60 w/cm^2 maximum heat flux) and at exposures of prime interest ($\sim$2.5 x 10^{20} fissions/cm^3). Fourteen capsules (one with a prototypic fission gas plenum) consisting of short lengths of EBWR fuel rods are being irradiated in the MTR, and eighteen (six with plenums) have been discharged. Maximum estimated exposures of the in-reactor and discharged specimens are 2.7 x 10^{20} fissions/cm^3 (10,000 Mwd/ton of fuel) and 2.3 x 10^{20} fissions/cm^3, respectively.

Underwater Equipment Development. Several dozen specimens of two overlapping Zircaloy strips, 3/16" wide by 0.010" thick, were spot

welded together under water. This material is the same as that used for binding the 19-rod cluster fuel elements. Half of the specimens had only one weld while the other had two, approximately 1-1/8 inches apart. Destructively tested specimens were strong, each pulling a button approximately 1/16 inch in diameter, and demonstrated characteristics as good as those welded in air.

All samples were subjected to 64 hours of autoclaving at 400 C and 1000 psig, which is equivalent to about 300 days under reactor conditions. There was no apparent corrosion after 20 hours. After 44 hours, there was a light graying in the weld. Sixty-six hours produced only a slight increase in graying, but the strength of the bond should not be affected.

Reactor Engineering Studies

PRTR Pressure Tube Monitoring. Following a high $\Delta\rho$ trip, the Zr-2 pressure tube in the FERTF was inspected and the inside diameter measured. Diameter measurements showed no change. Visual examination disclosed no unusual mechanical damage to the inside surface, but beginning at the point in the tube corresponding to the lower end of the fuel element, a very distinct change in surface reflectivity was observed. Below the lower end of the fuel element (inlet end of the pressure tube) the inside surface is moderately bright. From the lower end of the fuel element to the outlet nozzle, a dark and nonreflecting inside surface is believed to be attributable to buildup of a film that rubs off on the inspection instrument. This increase in surface film exists throughout the reactor, but it is much darker in the FERTF.

The flaw in tube 5526 appears to be a lamination which became swollen by the production of a reaction product. The reaction product has not been identified. Evidence has been collected which indicates this lamination was produced by tube fabrication processes.

The ultimate hoop strength at 550 F (288 C) of irradiated PRTR Zr-2 pressure tube specimens is indicated to be independent of microstructure at exposures of about 6×10^{20} nvt fast (E > 1 Mev) or more. This evidence came from an elevated temperature burst test of a specimen which is believed to have part cold worked and part annealed microstructure. Hoop elongation on the specimen was 20% and the burst failure was a pinhole.

A 1/16" long crack in an irradiated PRTR tube specimen did not propagate, but the tube specimen burst at a pressure of 8280 psig. The 1/16" long crack was produced by burst testing at 430 C. The specimen swelled plastically 16% in the high temperature test. In the room temperature test there was no plastic swelling.

Decontamination Studies. Eight combinations of acidic solutions (sodium bisulfate, citric acid, hydroxyacetic acid, oxalic acid, peracetic acid) were tested to dissolve PuO_2 samples. All the solutions dissolved only about 10^{-5} grams of Pu per liter of solution.

A dummy element was exposed in the IRP Loop for three days at 300 C to test an end seal proposed to cap sectioned pieces of irradiated mixed-oxide fuel rod for ceramic fuel washout studies. The end fittings appear very satisfactory.

Fretting Corrosion - PRTR Tests. Recent vibration measurements taken at PRTR were 8.0 ± 1.0 mils for both tubes 1653 and 1354. This is about the same amplitude observed during several previous operating periods. Zirconium analyses of the primary coolant were generally below one ppb, except for two samples showing 2.3 and 1.2 ppb. There were no "events" at the reactor which would indicate any reason for these higher values. A series of tests in PRTR are planned in which HX-1 steam pressure will be varied from 320 to 405 psig, while monitoring vibration, tube flow, and pressure data. Tube and gross water samples will be obtained for zirconium analyses.

Calibration of transducers which have been used on the PRTR monitor system indicated that the transducer used on tube 1653 was in error by about 10% at 30 cps. The damping characteristics were also altered. Indications are that this transducer had been damaged by radiation and/or high temperature. The other transducers appeared unaffected except for a very slight reduction in sensitivity.

A calibrating shaker system has been completed which allows the calibration of a complete monitor channel consisting of the transducer, the electronics, and the recorder, thus eliminating the theoretical calibration previously required.

Fretting Corrosion - Ex-reactor Tests. A standard UO_2 fuel element with 1/4 inch support pads was exposed to 125 F, 550 psig, and 120 gpm coolant conditions in EDEL-I with the inlet jumper externally vibrated at a frequency of 20 to 25 cps and an amplitude of 30-37 mils. The reduced temperature and pressure were required for safety considerations. The impressed vibration caused the midpoint of the tube to vibrate at 47 cps and an amplitude of 35 mils. Four tests were conducted under these conditions. These had total cycles of 415,000; 476,000; 409,000; and 900,000, respec-

Inspection of the tube after the second run revealed maximum fretting corrosion marks of 0.7 mil at the lower supports and 0.3 mil at the upper supports. The marks indicated a torsional movement of the fuel element, with perhaps 1/2 inch wide marks associated with the 1/4 inch pads at the upper and lower pad locations. The fuel element also showed fretting evidence, being bright in appearance on the pads. Zirconium samples taken before and after the tests were analyzed as 2.9 and 3.8 ppb for the first test and 1.5 and 1.3 ppb for the second. No explanation is available for the 2.9 ppb initial reading, though it might have been due to residual Zr in the system.

The third test increased the depth of the lower support mark to 1.25 mils. Before and after zirconium samples analyzed at 6.6 and 9.4 ppb, respectively.

The fourth test produced two new marks at the lower support pads with depths of 0.6 and 0.25 mil. Zirconium analysis for this test have not been received. Induced vibration of the midpoint of the tube had an amplitude of 26 mils in both tests three and four.

Prior to the impressed vibration tests a "control test" was run in EDEL-I with standard UO_2 fuel element with 1/4 inch support pads exposed to 530 F, 1050 psig, and 120 gpm coolant conditions. No "artificial" means, such as sharpened pads or induced vibration, were used to accelerate or promote fretting. After 419 hours of hot operation and 64 hours of cold operation, visual inspection of the tube revealed two lower bracket pad marks of less than one mil in depth. Also evident were individual rod wire wrap marks including one of 2.5 mils depth. This mark was produced by the first wire wrap immediately above the lower end bracket, though it is not definite that the mark was produced during this operating period. Zirconium samples taken concurrently with this test analyzed less than 0.15 ppb.

In continuing tests of fuel element hardware design, a UO_2 fuel element was exposed to 530 F, 123 gpm coolant conditions in TF-7 for 830 hours. Two of three centering feet on both the upper and lower end brackets were sharpened, and it was not wedged as in the previous test. External vibration with a peak-to-peak amplitude of 0.004 inch was applied at the midpoint of the test section during the test.

Inspection of the tube upon completion of the run revealed fretting marks 2 to 3 mils deep associated with the unsharpened feet. No

fretting marks corresponding to the sharpened feet were found. Why fretting occurred at the 1/16 inch wide unsharpened feet and no fretting occurred at the sharpened feet has not been determined. It appears to indicate that fretting inducing phenomena exist that can "over-ride" pad width.

As a comparison, this test had 2 to 3 mils penetration in 830 hours where the previous test, in which the fuel element was wedged, had 1 to 2 mils in 1355 hours.

Calandria-Shim Rod Assembly Helium Seal Testing. Corrosion problems in the PRTR core cavity indicate that heavy water vapors may be leaking into the dry gas system. One of the suspect points is the calandria-shim rod helium gas seal. Tests of this seal were conducted using the test fixture and machined aluminum "O" rings. These "O" rings exhibited about the same leak rate as the present gaskets. Both types of gaskets were very sensitive to angular misalignment of the mating flanges.

A test assembly with a flat lower flange and a spherically contoured upper flange, when used with the "O" rings, had comparable leak rates but were not susceptible to misalignment.

A ring with a diamond-shaped cross section showed no significant difference compared with the "O" rings. Its primary advantage is that it is easier to fabricate. A report, HW-83507, "PRTR Shim Rod Helium Seal," covering the work to date is being prepared.

PRTR High Power Density Core. A rough draft of the technical design criteria for PRTR high power density core has been completed, although some further supporting information is being developed on the use of chemical shim for saturable poison transient control and on the method of administering boiling burnout heat flux limits. The criteria cover the reactor performance capabilities, reactor core, fuel, primary system, control including chemical and mechanical shims, other auxiliary systems, and "physics experiment" core.

Fuel Re-Use. A simple correction was devised for the fuel losses inadvertently included in all recent fuel re-use economic calculations. Most of the main body of the report (60-70%) has been completed.

Thermal Hydraulics Studies. A modified method of calculating boiling burnout limits was developed for possible use for the PRTR. The purposes of devising a new method are:

(a) Establish in detail a calculational method which will standardize the method for determining boiling burnout limits for the PRTR.

(b) Provide a method of determining boiling burnout limits of sufficient flexibility to accommodate all potential ranges of operating variables of the PRTR, including such things as flow rate, inlet temperature, and fuel element design.

(c) Provide a method which can easily accommodate new information, such as improved boiling burnout relations or new knowledge of reactor flux distribution.

The modified method proposes to handle those uncertainties in process variables whose magnitude is known quantitatively in an exact analytical manner. The method further proposes to account for those variables which cannot be identified quantitatively by requiring that the burnout heat flux be higher than the operating heat flux at all points along the fuel element by some factor. The proposed method differs from the current one in that it proposes to identify these variables and assign a factor to each reactor than lump them together into one factor as is now being done. The advantage of this approach is that it makes the incorporation of new knowledge in these uncertain variables easier. Finally, the modified method does not propose to use a maximum heat flux or a maximum tube power as a limit. The maximum tube power permitted by boiling burnout will vary with changes in fuel elements and operating conditions. Properly, a boiling burnout limit should recognize this and the new modified limit proposes to do so.

2. Plutonium Ceramic Fuels Research

Vibrational Compaction - Fuel Relocation. A 3/8" OD, 0.035" wall stainless steel tube, 18" long with a 0.110" tungsten wire down the middle, was vibrationally compacted with UO_2 to 85% theoretical density using the following mix: -12 +14 mesh, 68 wt%; -60 +80 mesh, 15 wt%; -200 mesh, 17 wt%. This mix was predicted by the theoretical model for powder packing.

The rod is being assembled in a water jacket. Resistance heating of the tungsten wire will be used to generate a central void for fuel relocation studies.

PuN-15 vol% Pu Cermet Irradiation. Examination of a PuN-15 vol% Pu cermet irradiated to an estimated burnup of 35 x 10^{20} f/cm^3 showed that a portion of the specimen was converted to a fine powder. Some reaction product or condensate was observed on the aluminum blocks facing the wafer specimen.

3. Ceramic (Uranium) Fuel Research

Thermal Expansion of Single Crystal UO_2. The thermal expansion of a well characterized single crystal specimen of UO_2 was measured. Some of the measured chemical and physical properties of the sample material are: oxygen to uranium ratio 2.00, density 99+% TD, porosity <0.1% (<0.06 micron dia. pore), impurities <200 ppm (major constituents Fe, Si). The sample was heated and cooled at a rate of 3.5 C/min to 1600 C in a vacuum of 2 x 10^{-5} torr in an alumina sample holder. The thermal expansion, measured on a pushrod dilatometer was 12.1 x 10^{-6} C^{-1} between 300 C and 1600 C. It appears that there may be a discontinuity in the thermal expansion starting at approximately 1400 C. This temperature range will be investigated more closely.

Effects of Stoichiometry of UO_2 Thermal Conductivity. Irradiation was completed on the first of a series of UO_2 melting tests investigating the effect of stoichiometry on thermal conductivity during and after reactor startup. These tests utilize pressed and sintered UO_2 pellets 3.455 cm (1.360-inch) in diameter. The stoichiometry is varied by adding uranium metal to the pellets and heating in vacuum. Tungsten spheres are added to the pellets as markers to determine the initial melt radius.

Irradiation of Thoria. A thoria element originally containing 680 ppm nitrate, added as $Th(NO_3)_4 \cdot 12\ H_2O$ released 180.2 ml of gas, 170 ml of which was N_2, after 1.1 x 10^{20} nvt exposure in the MTR. No cladding corrosion was revealed by metallographic examination.

Fuel Washout Studies. Five irradiated PRTR fuel rods with different fuel fabrication history were transferred to the Radiometallurgy Laboratory for sectioning. Approximately 12-inch rod sections will be slotted, capped, and subjected to simulated reactor coolant flow conditions to develop fuel washout data.

Enriched Mixed Oxides. About 1 kilogram of 15 wt% PuO_2-UO_2 (93% enriched) was pneumatically impacted to 95% of theoretical density. The oxides were ball milled 67 hours before impaction to assure a uniform PuO_2 distribution in the UO_2. The PuO_2 distribution was uniform as measured by autoradiography and chemical analysis.

UO_2-PuO_2 Homogeneity Studies. No gross inhomogeneities in plutonium concentration were found in a sample of impacted, 64-hour ball milled UO_2-20% PuO_2 analyzed by the electron microprobe. It is felt that this material should operate satisfactorily as a fast reactor fuel with regard to transient heat transfer and subsequent U-238 Doppler broadening.

Nupac Grade UO_2 Powder Specifications. Specifications were written for UO_2 powder to be used in the pneumatic impaction (Nupac) process. An empirical test was included for tap density measurement of the UO_2 powder before purchase.

Tube-in-Tube Fuel Development. Vibrational compaction loading of fused UO_2 particles in a thin wall Zr-2 clad, tube-in-tube fuel element resulted in greater than 86% theoretical density in both the inner tube and the outer tube. Classification of the crushed UO_2 powders was performed according to ideal packing calculated by mathematical models. Both the inner and outer tube have been subjected to 400 C and 1500 psig with no apparent effect on the inner tube and a slight indentation on the outer tube clad adjacent to one end cap. Loss of fines was experienced at this same area during loading, and low density at this point probably explains the deformation. High temperature and pressure autoclaving is continuing.

BeO-PuO_2 Studies. All six of the small cans of BeO-nickel coated PuO_2 impacted material have been opened. The BeO matrix appeared to be bonded in all of the samples. Because of the low tap density of the very fine grained BeO, there was excessive can wrinkling and deformation of the ceramic. There was some indication of segregation and a considerable amount of stratification in the material. The stratification (layers of mixed ceramic separated by cracks) was a result of the low tap density.

Three of the samples had MgO added as a sintering aid in case the BeO did not bond. In two of these samples (1/2% MgO, 1% MgO), the MgO did not appear to aid in the bonding of the BeO. In fact, the compact was more friable than with the pure BeO. The other sample with 2% MgO addition appeared to be the strongest of all samples impacted.

UO_2 Niobium Cermets. A highly loaded UO_2-niobium cermet, clad with thin wall niobium tubing and sealed with powdered niobium end caps was fabricated by pneumatic impaction. Hot swaging of the cermet rod is to be evaluated as a means of providing uniform dimensions and bonded core. Cold swaging of a previous niobium cermet resulted in a fractured niobium matrix.

Rectangular Dynapak Tooling. The first use of rectangular tooling in the Dynapak machine was successful. The tooling consisted of a 1-3/4" x 6", H-13 tool steel die and punch. The die cavity was 2-3/4" deep. However, modification of the backup plug could increase the length to approximately 6". The base of the punch is 8" diameter, the same as that used for the 4" diameter tooling. No serious alignment problems were encountered.

The tooling was used in making 12 impactions. The cans used for these initial impactions were 2" long. The maximum pressure developed was 277,000 psi. Due to the short stopping distance, only 1100 psi fire pressure was required to produce this impaction pressure.

4. Basic Swelling Studies

Irradiation Program. A general swelling capsule containing as-extruded and beta heat-treated specimens of high purity, 1.44 at% enriched uranium reached goal exposure and was discharged. It had operated successfully at 625 C (1157 F) regardless of the operating state of the reactor.

The first controlled pressure-temperature swelling capsule was charged into a reactor and is operating successfully at 450 C (842 F) and 1000 psi. High purity uranium, U + Fe-Al, and U + Fe-Si specimens are included in this capsule. This irradiation will provide insight into the effect of pressure on "growth" induced, grain-boundary tearing. A similar capsule is under construction for subsequent irradiation.

Post-irradiation Examination. Optical and electron microscope examination of specimens of U + 400 ppm Fe - 600 Al, U + 140 ppm Fe - 95 Si, and high purity uranium irradiated to a burnup of 0.16 at% have been completed. As expected from density measurements, the U + Fe-Al samples exhibited the least porosity. A direct comparison of the microstructure of the U + Fe-Al and U + Fe-Si (irradiated at 605 C, or 1121 F) which had received a gamma-alpha treatment was possible. The former showed very small pores on grain boundaries and in some cases adjacent to second phase particles. Matrix porosity and tearing were completely absent. In the U + Fe-Si specimen, pores were present in the matrix, with the largest pores being located on twin bands. Some microcracking parallel to twin bands was also noted. The alloys which received a beta-alpha treatment (irradiated at 585 C, or 1085 F) exhibited extreme porosity, largely found on twin bands. Extreme porosity was observed on the high purity samples, again in agreement with density measurements.

Supplemental Studies. Transmission electron microscopy of uranium alloys has continued. Particle size measurements are in agreement with those established by replica techniques. Wafer samples of high purity uranium and uranium alloys which were irradiated to 10^{17} (thermal) have been examined by transmission microscopy. Analysis of the micrographs is in progress.

5. Irradiation Damage to Reactor Metals

Alloy Selection

Several nickel base alloys are being studied to determine the effects of irradiation and environment upon their mechanical properties. These alloys are being irradiated at 280, 580, and 740 C (536, 1076, and 1364 F) and tested at both room temperature and 700 C (1292 F). During the past month, twelve 700 C tensile tests on irradiated nickel base and stainless steel alloy specimens were completed. These tests were performed in air without extensometers. Further elevated temperature tests on nickel base and refractory metal alloys are planned.

Room temperature tensile tests on control specimens of various nickel base alloys exposed to 580 and 740 C (1076 and 1364 F) helium were completed and the data compared to that for specimens irradiated under similar thermal conditions to an exposure of 9×10^{19} nvt (E >1 Mev). In general, specimens of Hastelloy X-280, Inconel 600, Hastelloy N, and Inconel 625 showed an increase in strength but a loss in ductility after the irradiation. Specimens of Hastelloy R-235 showed a decrease in both strength and ductility after irradiation under the same conditions, while Incoloy 800 specimens showed a decrease in strength and an increase in ductility.

Metallographic examination of Inconel 600 irradiated to an exposure of 9.25×10^{19} nvt at 740 C (1364 F) was continued. After repolishing and etching the specimen, gas pores could not be found. This is contrary to what was reported last month and can be attributed only to variations in the metallography techniques being used. The specimen will be annealed and the examination repeated.

In-Reactor Measurement of Mechanical Properties

In-reactor creep tests on annealed 304 stainless steel at 500 and 600 C (932 and 1112 F) and 20,000 psi stress are continuing. The creep rate for the 500 C test is less than 2.5×10^{-7}/hr. The

600 C (1112 F) in-reactor test is exhibiting the same creep rate at 700 hours, 9.7 x 10^{-6}/hr, as reported for 170 hours in the last monthly report. A parallel ex-reactor test at 600 C was interrupted after 250 hours.

Activation energy studies on annealed 304 stainless steel were performed at 30,000 psi creep stress at 600, 625, and 650 C (1112, 1157, and 1202 F) and at 40,000 psi at 500 C by the temperature change method. Computer analysis of the data will be required before any activation energies can be reported.

Irradiation Effects in Structural Materials

The purpose of this program is to investigate the combined effects of irradiation 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.

Zircaloy-2 specimens containing 70% cold work have been irradiated at 50 C (150 F) in the ETR to an exposure of 5 x 10^{21} nvt (>1 Mev). These specimens are currently being tested at room temperature and examined metallographically. Additional Zircaloy-2 tensile specimens, in both the annealed and cold worked conditions, which were irradiated in the ETR G-7 hot water loop at 290 C (540 F) have been sectioned along the three principal planes and examined metallographically to determine hydride orientation. One group of specimens contained approximately 100 ppm hydrogen after an 1850-hour exposure. A second group of specimens exposed for 3460 hours contained approximately 175 ppm hydrogen. The integrated neutron exposures for these two groups of specimens were 6.4 x 10^{20} and 1.4 x 10^{21} nvt (>1 Mev), respectively.

Similar hydride orientations were noted for both groups of specimens with similar fabrication history. In the cold worked specimens the hydride platelets nucleated almost exclusively at the rolled-out stringers of second phase particles and grew along these stringers coplanar with the rolling plane. In the annealed material, however, the second phase stringers had only a nominal effect on the resultant hydride orientation. The more random orientation and the large fraction of transgranular platelets indicate growth of the hydride along normal habit planes.

A difference in the tensile properties of Inconel X-750 heat treated in air and in helium-filled capsules is primarily the result of variation in grain size. Grain growth is extremely rapid at the

solutioning temperatures of nickel alloys. Differences in heat conduction of air and helium appear to affect grain size at these elevated temperatures. With equal time at temperature, the grain size variations ranged from ASTM 1-2 in helium-filled capsules to ASTM 4-5 in air-filled capsules.

Work to improve in-reactor stability of nickel base structural alloys is continuing. Controlled precipitation of intermetallic phases in the matrix rather than in grain boundaries might extend the stress-to-rupture life of an alloy. Combination of pre-irradiation cold work plus aging treatments selectively precipitates brittle phases in the matrix of Hastelloy X-280. The pretreatments, however, must be optimized to prevent ductility loss from excessive cold work. Previous results showed 26% cold work to be too much. Four additional levels of cold work -- 0, 10, 15, and 20% -- are being investigated combined with a constant aging time of 100 hours and two aging temperatures -- 1000 F (538 C), 1500 F (816 C). Control and irradiated material will be evaluated by means of the stress-to-rupture and tensile tests.

Metallographic methods have been used to determine the presence of martensite in 304 and 348 stainless steels. Tempering at 430 C (806 F) for one to two hours and electrolytic etching with a solution of 10% oxalic acid provides an especially clear picture of the structure. The amount of martensite present appears to agree with previous estimates made from the changes in the magnetic susceptibility. About 30 to 35% of martensite is present in 70% cold worked 304 stainless steel. The oxalic acid solution does not give good results on untempered specimens. An etch that will be satisfactory for use on untempered specimens is being sought.

The construction and calibration of the high rate loading equipment was completed. This equipment is being used to study the fracture processes of metals. Preliminary results obtained from notched specimens of A302B indicate that a correlation between fracture behavior and tensile deformation behavior is possible. Such a correlation is made possible by the insight gained by testing at the very high rates of loading.

Environmental Effects

The special ETR G-7 loop test with hydrogen injection was started on July 19, 1964. Hydrogen and oxygen in the coolant, pH, and water conductivity are monitored daily, and hydrogen is added to the loop by way of the ion exchange system in amounts sufficient to maintain hydrogen levels above 15 cc per kg of water. On the whole, this special hydrogen test is progressing satisfactorily.

Metallographic sections of four irradiated notch tensile and four irradiated tensile test specimens were examined during the month of August 1964. Some of these had been exposed for 264 days at 540 F (282 C). Oxide film thicknesses continue to fall in line with data previously obtained. Hydrogen pickup fractions ranged from 40 to 85%, and one annealed, long-exposure specimen showed evidence of a hydride concentration gradient decreasing toward the center of the specimen. Long exposure, 40% cold worked material exhibited only about half the oxide thickness found on annealed material. Also, for long-exposure material, the thickness of oxide growing in a direction normal to the rolling plane was found to be 1.5 to 2 times that of oxide formed on sample edges.

ATR Gas Loop Studies

Molybdenum Oxidation Test. An apparatus has been set up in the control room of the model gas loop to monitor the effect of the gas loop atmosphere on the molybdenum heating elements. The test is not a corrosion study as such, but it is designed to yield qualitative information necessary to determine when, how hot, and how long the model gas heater can be run.

The initial results of the test indicate that for 24 hours at 2200 F to 2372 F (1204 C to 1299 C) in flowing gas from the loop helium source, strips of molybdenum heating elements lose 0.1% of their weight. In these tests the gas flow is such that molybdenum samples run at 2400 F (1316 C) with the flow off, and at 2200 F with the flow on. The molybdenum discolors after 15 minutes at 2200 F, but there is no visual difference in discoloration between 15 minutes and 24 hours at this temperature. If this quality of gas is maintained as the loop is heated, it should be safe to take it up to the operating goal of 2000 F in the test section.

Sparking Potential in High Temperature Helium. The potential required to initiate sparking in high temperature helium has been determined as a function of electrode gap length. It is found that a potential of 130 V (r.m.s., 60 cycle AC) or more, is required to initiate sparking, even at very short gaps, at temperatures to 2282 F (1250 C). At potentials greater than 130 V, decreasing the temperature allows use of shorter gaps.

High Temperature Oxidation of Candidate ATR Materials. Additional oxidation data have been obtained at 1120 C (2048 F) for Hastelloy X and Haynes 25 superalloys. The scale formation was

followed as a weight gain function to times of 5000 minutes. The oxidizing atmospheres considered to date for Hastelloy X have been oxygen at 25 mm, 4 mm, 97μ and 39μ pressure, carbon dioxide at 80 mm and 23 mm, carbon monoxide at 25 mm and air at NTP. For Haynes 25, the oxidizing atmospheres have been oxygen at 100 mm, 92μ and 42μ pressure and water vapor at 28 mm.

Although no rigorous interpretation of the data has been attempted, the kinetics of attack for each test seem to follow a parabolic or mixed parabolic rate law. This is reasonable since during the oxidizing tests the scale is adherent and film growth might be expected to be some function of scale thickness.

For Haynes 25, there is rapid spalling of the scale as the temperature is decreased from 1120 C (2048 F) to room temperature. The temperature of the most rapid spallation occurs at 480 C (896 F).

Gas-Solid Reactions at High Temperatures. Oxidation rates of molybdenum and TZM alloy (Mo - 0.08 wt% Zr - 0.5 wt% Ti) at 5×10^{-3} and 5×10^{-4} Torr air at 1000 C (1832 F) -- based on descaled sample weights -- were previously reported. Metallographic examination of cold worked TZM in 5×10^{-4} Torr air revealed internal oxidation of 1.9 mil penetration in 266 hours. Penetration of annealed TZM was negligible, though metallographically observable. Lowering the air pressure from 5×10^{-4} to 5×10^{-5} Torr lowered the oxidation rate by a factor of two as contrasted with an order of magnitude when the pressure was lowered from 5×10^{-3} to 5×10^{-4} Torr. Probably volatilization of the trioxide becomes less important at the lower end of the pressure range.

Circulator Performance Curves. The pressure rise across the circulator was measured at speeds of 10,000 to 25,000 rpm and at helium flow rates of 100 to 500 pounds per hour. At 500 pounds flow and 25,000 rpm, the pressure rise is 7.8 psi which is about 20% less than the vendor's calculated pressure rise.

6. Nuclear Graphite

The Radiolysis of a Mixture of Carbon Monoxide and Water Vapor Sensitized by Helium. A study of radiation induced reaction in carbon monoxide-water vapor mixtures has recently been reported.[1] In current work, the effect of helium on this reaction is being explored. Capsules containing known concentrations of CO and H_2O in roughly equal quantity and helium ranging from 0 to 99.4% were irradiated in a cobalt-60 gamma field of 2.7×10^6 R/hr. The gases were analyzed for reaction products gas chromatographically. Hydrogen, carbon dioxide, methane, and trace amounts of ethane were formed during the radiolysis.

The summed G values (100 ev yields based on total energy absorbed) for H_2, CO_2, and CH_4 were invariant at 15.1 ± 0.7 for the seven mixtures ranging from zero to almost 99% helium, indicating a very high efficiency of energy transfer from helium to the reactants. The final mixture, containing 99.4% helium showed a somewhat lower extent of reaction, having a G value of 9.5. Methane production was low, with a G value averaging less than one. Methane formation may be favored slightly by helium sensitization.

Kinetics of the Reaction of Carbon Dioxide with Hydrogen. Further experiments with a reaction vessel of smaller size and revised geometry showed that the 0.3 sec induction period reported in HW-83445 A was due to apparatus design and not a real kinetic effect. The rate constants and activation energies determined in the revised apparatus confirmed earlier results.

Inhibition of Graphite Oxidation. Previous tests with CCl_2F_2 as an inhibitor of the air oxidation of graphite have shown two effects on the rate. The oxidation of graphite is inhibited by adsorption of chlorine; vanadium and other oxidation catalyst impurities are removed. While the impurities are being removed in the presence of air, there is a concurrent increase of oxidation rate; this is followed by a decrease in rate. Since this initial increase has not been noted with chlorine as inhibitor, fluroine-containing-products from the decomposition of CCl_2F_2 are evidently responsible. To obtain further information on the interaction with impurities, graphites of different purity have been oxidized.

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[1] G. L. Tingey, "Radiolysis of Mixtures of Carbon Monoxide and Water Vapor," HW-SA-3440, April 6, 1964.

A pure graphite, SP-6, with a lower neutron absorption than EGCR graphite was studied. In this material, vanadium, a principal oxidation catalyst, is significantly less. However, the oxidation rates of SP-6 in air and in air with 1/2 percent CCl_2F_2 as inhibitor, were both higher than those for EGCR, and the apparent activation energy was less. This relation is the inverse of that expected. Surface area measurements are being obtained to help explain these results.

EGCR Graphite Irradiation. The series of capsules for the long-term irradiation of EGCR graphite continues satisfactorily. The eighth capsule, H-3-8, was removed from the GETR after completing four cycles (100.3 effective full-power days) of operation. All nine thermocouples functioned properly for the entire irradiation. Upon disassembly, the capsule and samples were found to be in excellent condition. The crack structure visible on some samples appeared to be unchanged. The samples, flux monitors, and a sample of the carbon deposit from the can wall are being shipped to Hanford.

Annealing of Irradiated Graphite. An exploratory experiment was performed to test the feasibility of measuring changes in thermal expansion caused by irradiation and subsequent annealing of graphite.

The thermal expansion between 25 and 700 C of irradiated graphite samples was determined before and after annealing at 2100 C for one hour. For CSF graphite irradiated to 6400 Mwd/At at 550 C, about 4% decrease in thermal expansion transverse to the extrusion axis was noted after annealing; for TSX graphite irradiated to 2000 Mwd/At, the respective change was about 5%. Little, if any, change was found for parallel samples of EGCR graphite.

7. Boronated Graphite Studies

2-C Irradiation Tests. The 2C-2 capsule has been discharged, and the samples have been measured for length changes incurred during the last irradiation period. The capsule performed satisfactorily during the entire period. The blanket-gas pressure increased ~25% during the irradiation from the helium formed in the $B^{10}(n, \alpha) Li^7$ reaction, an amount roughly equal to the expected increase.

The dimensional change data after exposures to 1.45×10^{20} and 2.55×10^{20} nvt (E >0.18 Mev) show well established trends.

1. The grey samples both parallel and transverse to the extrusion axis show only expansion. The greatest expansion (almost 1.5%) was found in the grey material containing 7% boron which had been irradiated at 370 C. Those samples irradiated at 450-500 C had expanded almost 1%.

2. The 7% boron grey parallel and transverse samples behaved similarly indicating little anisotropy. The 5% boron samples showed greater variation in dimensional change between parallel and transverse samples.

3. The black samples behaved more like polycrystalline graphite. All parallel samples showed contraction. Of the transverse samples, the 5% samples expanded initially and then contracted; the 7% samples showed only contraction.

4. The dimensional change behavior is correlatable with structure disclosed in photomicrographs. The 7% grey material is almost completely recrystallized and is the least anisotropic. The 5% grey is less recrystallized and is more anisotropic. The 7% black material continues this sequence and the 5% black has an appearance similar to polycrystalline graphite with identifiable particles of boron carbide present.

5. The extensive dimensional change in the grey material is undoubtedly due to the high degree of damage from the $B(n,\alpha)Li$ reaction of the highly dispersed boron.

The 2C-3 capsule which will extend the exposure on the samples is being readied for insertion. New carrier dimensions were used since the samples that were in both the 2C-1 and 2C-2 capsules had expanded diametrically and closed a heat transfer gap. The new carriers are constructed to operate successfully with an additional 3% expansion of the samples.

The instrumented lead capsule, GEH-23-9, containing one high- and one low-temperature sample, satisfactorily completed its proposed cycle of exposure in the ETR. The capsule operated at average sample temperatures of approximately 920 F and 750 F (493 and 400 C). The initial, or startup, temperatures were 945 F and 756 F (507 and 407 C). Based on the environmental thermal-neutron flux as the controlling heat-generating parameter, all six non-instrumented capsules were estimated to be within 10% of the initial design temperatures.

In an initial attempt to recover the samples, all except three stuck in the capsules. These three were 7 wt% grey material oriented parallel to the extrusion axis. Two samples were exposed to less than 1 x 10^{20} nvt, thermal or fast flux, and showed slight, 0.1 to 0.2%, contraction. The third irradiated at 490 C (920 F) to about 5.5 x 10^{20} nvt, thermal or fast flux, showed an expansion of 0.7% in reasonable agreement, on a comparable basis, with the 2C results.

8. Aluminum Corrosion and Alloy Development

The aluminum clad fuel elements from C-1 Loop were visually examined in C-basin. The elements had been exposed to recirculating water at 260 C outlet temperature and pH 4.5 with phosphoric acid for 1400 hours. All of the elements except one were covered with a blotchy reddish-brown crud over about half the surface and did not appear too badly corroded. The crud-free element was the next to last downstream element, and it was the most downstream of the three X-8001 clad elements. This element appeared to have a slightly roughened surface which was aluminum colored, indicative of moderate nonuniform corrosion. Other fuel elements in the charge exhibited smooth surfaces, indicating little corrosion or very uniform corrosion. These elements will be cleaned and weighed to obtain quantitative corrosion data.

9. Metallic Fuel Development

Irradiation of Thorium-Uranium Fuel Elements. Irradiation of three tubular Zircaloy-2 clad thorium-2.5 wt% uranium-1.0 wt% zirconium fuel elements continued successfully in the ETR-P7 loop. The fuel elements are currently operating at a maximum temperature of 505 C, a surface heat flux of 59 cal/sec-cm^2 (7.9 x 10^5 Btu/hr-ft^2) and a specific power of 55 watts/gm (167 kw/ft). The integrated exposure is 2.9 x 10^{20} fissions/cm^3 (8500 Mwd/ton). Fuel swelling continues to be no more than that expected from the solid fission products. The measured volume increase at 8500 Mwd/ton was 0.9%.

Irradiation Testing of Metallic Uranium with Submicron Uranium Carbide Dispersions. The irradiation performance of fuel rods containing a submicron dispersion of uranium carbide in uranium is being evaluated in the ETR. Of the three irradiation test capsules, two contain fuel rods identical in uranium compositions, but with one having a uranium carbide size of 2-5 microns produced from arc-melted uranium and the other a uranium carbide particle size of less than 0.5 micron produced from the uranium shot. The third capsule contains two fuel rods with the fine carbide.

One capsule has achieved goal exposure of 0.3 at% burnup at a maximum fuel operating temperature of 550 C and has been shipped to Radiometallurgy for examination. The remaining two capsules operated at a maximum fuel temperature of 600 to 625 C during the first cycle of operation and at a maximum temperature of 475 to 500 C during the second cycle of operation. Both capsules have achieved an exposure of 0.1 at% burnup.

10. Advanced Reactor Concept Studies

Segmented Fast Reactor. A review was begun of fuel cycles proposed for other large fast reactors in order to make a preliminary determination of the most promising fuel cycles for this study.

Plutonium-Fueled Compact Fast Reactor Studies. A rough draft of document HW-83535 (Confidential), a summary report describing investigations made to date on plutonium fueling of compact fast reactors, has been completed and is circulating for comment.

11. Phoenix Fuel Program

MTR Experiment. Parametric studies to identify operating conditions which satisfy engineering, physics, and fuel fabrication requirements for a proposed MTR-Phoenix experiment have continued. Initial calculations were made on Pu-Zr fuel alloy. While engineering characteristics can be made acceptable, the Pu-Zr alloy growth behavior might become intolerable for successful long-term exposure. Thus, an alternate alloy, Pu-Al, is being considered. An engineering analysis was made which showed that acceptable metal-to-water ratios, power densities, and thermal hydraulic conditions can be established. However, core loadings having sufficient Pu content cannot be obtained with more conventional (less than 20 wt% Pu) alloys. An alloy of 30 wt% Pu or higher may be necessary to satisfy the physics performance objectives for the experiment. This may require some fuel development for the aluminum alloy fuel.

Since the final physics requirements will decide the scheme's feasibility, no one core design case has been selected as an optimum. Instead, the results of the engineering analyses are being presented in a manner that will allow rapid selection once the physics requirements have been developed.

Phoenix Application Survey. Preliminary considerations indicate that a likely market for Phoenix fuel reactors would be for maritime propulsion. Accordingly, a survey was begun of the previous economic analyses of maritime nuclear propulsion to determine the most promising type and size of Pheonix fuel reactor to consider for this

application and to establish the economic ground rules by which its performance must be judged.

Phoenix Fuel. Approximately 7500, 20 wt% Pu-Al discs, 0.020 inch thick, have been fabricated to close tolerances by the recently developed spiral machining process. Isotopic content of the discs range from 8 wt% Pu-240 to approximately 26 wt% Pu-240. The job is approximately 90% completed.

12. Nuclear Rocket Fuels Studies

Research and development in the field of nuclear fuels and alloy development in support of NASA programs continued. Details of these activities are reported separately via distribution directly to the sponsors.

D. DIVISION OF RESEARCH - 05 PROGRAM

1. Radiation Effects on Metals

This program is directed toward establishing the combined effect of impurities and neutron irradiation on the properties and structure of specific metals, and deducing from thermally activated recovery processes how the damage state can be altered. Present studies involve single and polycrystalline specimens of molybdenum, nickel, and rhenium.

Transmission microscopy of carbon-doped molybdenum irradiated to 10^{19} nvt and annealed at 750 C (1382 F) has disclosed the presence of a few large dislocation loops. Tilting experiments have identified the large loops as being interstitial in character. The plane of the loops has been determined to be (111). The Burgers vector could not be determined unambiguously, but it is assumed to be a/3 [111]. Because errors associated with measuring the diameter of the small loops are greater than the change in size during tilting, their character could not be determined.

The interaction of moving dislocations with radiation-induced defect clusters is being studied by observing a specimen in the electron microscope as stress is applied. In several instances the interaction of moving dislocations with clusters resulted in the formation of jogs. Channel formation was not directly observed, but several had formed as the test proceeded. Presumably, these form as the result of many dislocations interacting with clusters within discrete bands or channels. At no time did the clusters move or change contrast under stress. This is not surprising as the clusters are small and would tend to be stable.

Sections cut from one of the bent single crystals of irradiated molybdenum have been successfully thinned for transmission electron microscopy. These extremely small sections were difficult to thin and mount in the sample holder. A second crystal with a larger cross section will be sectioned and should be more suitable for thinning and observation.

Observations of an unirradiated molybdenum single crystal of identical orientation as previously tested, irradiated crystals have been completed. Results reveal the absence of any observable slip lines after bending equivalent amounts as on the irradiated crystals, and substantiate the conclusion that deformation on the unirradiated material is much more homogeneous. Considerable deformation may be required to produce observable offsets on the surface of the unirradiated crystal. It may be desirable to section the unirradiated crystal and compare dislocation distributions with that in the irradiated crystal.

Molybdenum foils containing 100-200 ppm carbon and 400-500 ppm carbon have been examined by x-ray diffraction after irradiation to 1×10^{20} nvt (E >1 Mev). The lattice parameters show considerable variation from sample to sample but were lower than the values previously measured for foils of the same composition irradiated to 1×10^{19} nvt. The line breadths are, however, much greater. After 1×10^{19} nvt exposure, the average breadth of the (400) peak was about 0.275° 2θ; after 1×10^{20} nvt, the corresponding value is 1.10°. The next task to be undertaken is to determine if the large increase in line breadth is due to stacking faults, lattice strains, or particle size effects.

A paper entitled, "Quench-Hardening in Polycrystalline Nickel," has been prepared for submission to Acta Met.

2. Plutonium Physical Metallurgy

The objective of this program is the derivation of fundamental information relative to (1) the kinetics and mechanics of the phase transformations in plutonium, and (2) the mechanisms by which monoclinic plutonium deforms.

A discontinuity at approximately 110 C (230 F) in the differential thermal analysis heating curve has been observed and reported by investigators at the Mound Laboratories. This discontinuity may be due to a phase change that is analogous to the delta prime phase. The specific volume-temperature curve of high purity plutonium derived from heating rates of 1 C (34 F) per hour revealed no discontinuity between 100 C (212 F) and 119 C (246 F). In the event

of a change in either crystal structure or atomic structure in this temperature range, it has been established that no volumetric change takes place.

The ultimate strength and yield strength of the beta phase in unalloyed plutonium is reported to be very low. The ductility of the beta phase is very high, and values up to 600% have been reported. These reported values were obtained on beta that had formed from alpha. No consideration was given to the effect that the parent phase might have on these properties. The ultimate strength and the yield strength of the beta phase are increased by a factor of 3 when the beta is formed from gamma instead of from alpha. For example, at 160 C (320 F) and at a testing speed of 0.05 in/min the ultimate tensile strength is increased from 8,000 to 23,000 psi; the yield strength is increased from 5,500 to 18,000 psi, and the percent elongation is decreased from 400% to less than 30%. As might be inferred from this data, the steady state creep rate of the beta phase that is formed from gamma is also decreased; it is only 0.2 to 0.5% of the creep rate of beta that is formed from alpha. This technique has been reported in detail in an invention report, HW-83754, entitled "Strengthening of the Beta Phase in Unalloyed Plutonium."

Microcracking, which is a serious problem in high quality plutonium, can be mitigated by rapid beta to alpha transformation. A technique based on this concept which yields plutonium that contains essentially no microcracks is described in an invention report, HW-83733, entitled "Production of Crack-Free High-Purity Plutonium."

Two chapter sections, entitled "Density Determinations of Plutonium" and "Application of Metallurgical Techniques to Plutonium," have been submitted for the Plutonium Handbook, edited by O. J. Wick.

E. CUSTOMER WORK

1. Radiometallurgy Laboratory

Examinations

The results of routine examinations and measurements are, or will be, reported as part of the sponsoring research and development programs. During the period June 29 to July 28, 1964, Radiometallurgy Laboratory output included:

Metallography samples processed	43
Photomosaics	5
Autoradiographs	15
Replicas (for electron microscopy)	9
Replicas (silicone rubber)	1
Burnup dissolutions	10
Fission gas sample collections	6
Vacuum induction furnace runs	14
Decladding dissolutions	2
Tensile tests (300 C & 700 C)	22
Rockwell hardness tests	2
Density determinations	26
X-ray analysis	10
Negatives processed	545

Equipment

Project CAH-136, Service Addition - 327 Building. Scope design was completed by Vitro Engineering and reviewed by Radiometallurgy. Preliminary detailed design work was started although all requested scope design changes were not made.

High Temperature Tensile Testing Machine. Elevated temperature tensile tests were conducted on button head tensile samples at temperatures of 1000, 1200, 1400, and 1500 F. Furnace temperature control was good. Within 30 minutes after reaching testing temperature, the temperature gradient along the specimen gage length was balanced so that the variation in temperature did not exceed ± 5 degrees at 1000 F. At temperatures above 1000 F the extensometer sample clamps slipped or loosened. This was caused by loss of clamp spring tension at this temperature and extreme necking of the specimen. A new extensometer clamp design approach will be necessary for temperatures over 1000 F. Flat tensile specimen grips were used successfully at temperatures up to 300 C. New grip holders have been fabricated from TZM (titanium-zirconium-molybdenum) alloy for use at temperatures over 1500 F. Tungsten carbide grip wedges are being designed for testing of flat specimens above 300 C. Inconel and other high temperature alloy grip wedges were not hard enough at room temperature to grip flat tensile samples. It is imperative that the grip wedge material be harder at all temperatures from room temperature to the testing temperature.

"B" Cell Modification. Two large, lead glass windows for installation in "B" cell are scheduled for shipment by the end of September. Preliminary cleanup and equipment removal was started in the north

half of the cell to permit removal of the door for machining of the window opening.

"E" Cell Metallographic Facilities. Work continued on installation of metallographic requirement in "E" cell. Fabrication of the remote metallograph is about 50% complete. An improved method of stage translation and rotation is being incorporated in the new metallograph. Design work on the grinders and polishers continued.

Remote Belt Sander. Fabrication of the remote belt sander sample holder was completed and the holder operated successfully during tests. Work continued in Tech Shops on fabrication of the sample manipulating device.

Light-Duty Master Slave Manipulators. Two light-duty, Model 8 type manipulators were received for use in B cell following completion of the cell modification now in progress.

Strain Gage Spot Welder. Fabrication of a spot welder to weld strain gages to irradiated process tubing before burst testing was started in Tech Shops.

2. Metallography Laboratories

Routine Metallography Laboratories activities will be reported as part of the sponsoring research and development component's work; however, items of unusual interest or representing departures from routine operations will be reported here.

During the report month 392 samples were processed, a total of 674 micrographs and macrographs taken, 1903 negatives printed, and 6886 prints processed.

A sample of pure technetium-99 was polished, etched, and photographed for the first time in this laboratory, and certainly one of the few times it has been done in this country. Since technetium is a low level radioactive element, special procedures were required to contain any possible contamination. Grinding of the sample was accomplished on a Buehler Automet polisher through 600 grit abrasive paper. Rough polishing was done on a Syntron vibratory polisher using water, Linde A abrasive, and Metcloth, followed by Linde A and water on Microcloth. Final polishing was accomplished with Metpolish #3 and water on Microcloth. Technetium metal work hardens easily, and consequently care must be exercised during the grinding steps. An extended

period of time on the vibratory polisher must be allowed for complete removal of any worked metal resulting from grinding. Etching was done electrolytically with 10% oxalic acid at 6 to 9 volts with the sample as the anode. The oxalic acid produces an epitaxial layer on the surface which responds brilliantly to polarized light and sensitive tint illumination. A color photomicrograph was prepared illustrating the grain structure of technetium.

3. High Temperature Lattice Test Reactor

Compatibility of Structural Materials with the HTLTR Environment. In a test to determine the effect of insulating brick material on graphite corrosion at 1200 C, two varieties of K-23 brick were placed in contact with graphite specimens in a simulated reactor atmosphere for 500 hours. The test results indicated that graphite corrosion was not accelerated by contact with the brick. In the period of this test the graphite underwent a weight loss of 0.8%.

HTLTR Full-Scale Mockup. Construction of the full-scale HTLTR mockup was completed, and checkout of the electrical system, safety circuits, and equipment systems including operation of the circulating blower and vacuum pump was completed satisfactorily. Fabrication of six rectangular cross section heater elements was completed, and installation of four of these was started. Eight of the 12 special material thermocouples have been received.

Design of the control elements for both the safety rods and control rods was completed, and fabrication of spool pieces for the control element was started.

4. EBWR Fuel Elements

Fifty-five of 474 ultrasonically tested Zr-2 cladding tubes gave indications of defects in excess of 0.001 inch. Metallographic examination was conducted in three selected indications to determine the nature and depth of the flows; cracks and impressed metal particles were responsible for the defects. Hydride measurement revealed concentrations of 8-10 ppm in the tubing. The tubes have been returned to the vendor for replacement.

The first shipment was made to Argonne of 810 EBWR UO_2-1.5 PuO_2 fuel rods. Forty-five special shipping containers will be returned in September for the final shipment of 702 fuel rods. Delivery of these fuel rods is ahead of the existing schedules for the Plutonium Recycle Demonstration Program at Argonne National Laboratory.

Recent chemical tests confirm earlier data that depleted UO_2 powder, prepared commercially from metallic uranium, contains a gas-evolving phase which is eliminated by a treatment in wet hydrogen at 1700 C. Vacuum outgassing tests at 1000 C show that large amounts of CO_2 and H_2O are removed by the purification process.

5. Other Customer Work

Nichrome Cermet Studies

Two UO_2 62 wt% nichrome cermet discs, 0.6" diameter, totally clad in nichrome, were prepared by a Nupac technique for compatibility tests. The Nupac dies are made of copper and are impacted at 700 C. The cermet discs are released from the die by dissolution of the copper in concentrated nitric acid.

Irradiation Samples for Phillips Petroleum Company

All work was completed, and the standards were sent to Phillips Petroleum Company.

Physics Fuel Elements

Discs, containing 3 g/cc UO_2 (69 wt% UO_2) were formed using an organic binder and carefully controlled heating rates. The 1.9" diameter by 3/8" thick discs machined satisfactorily, and the material appears to be suitable for HTLTR control rod sleeves.

Pu-Al I & E Fuel Elements

Two sample 3 wt% Pu-Al, I & E fuel elements have been fabricated and nondestructively tested to determine core to clad contact area. The Pu-Al core was cast and extruded into a common IPD I & E configuration. Aluminum cladding components were machined to close tolerance, and a slip fit of less than 0.001 inch clearance between metal and can was achieved.

Boiling Burnout for the ATR

Special consideration was given to the thermocouples to be used in the boiling burnout experiments with the electrically heated test sections pertaining to Advanced Test Reactor (ATR).

The surface thermocouples for the test sections will be held against the surface by coiled springs mounted on the OD of the thermocouple sheaths. A question was raised concerning the response characteristics of pressure contact thermocouples in comparison to sheathed thermocouples which are welded to the test section. Some simple experiments were conducted to determine these characteristics. The results show that certain pressure contact thermocouples will respond to a transient temperature change as well or better than a welded contact assembly.

A stainless steel strip (0.030-inch thick x 0.5-inch wide x 4.7 inches long) was electrically heated by low voltage AC power. A constant power input of about 2-1/2 seconds duration was used. The outputs from four thermocouples were recorded simultaneously on a fast recorder. One thermocouple was iron-constantan bare wire junction welded directly to the surface of the heater strip. A second thermocouple was a 1/16-inch OD sheathed thermocouple with the thermocouple junction electrically insulated from the sheath. The sheath was Heliarc welded to the heater strip with small addition of filler metal. This is typical of thermocouple installations used in the majority of test sections used in heat transfer work at Hanford, where the thermocouple sheath is attached directly to the test section and is referred to as a welded contact thermocouple installation. The other two thermocouples were of the pressure contact type using the helical spring arrangement. Contact pressure was in the range of two to three pounds force. The contact surface and area were varied as will be discussed subsequently.

Some results of the tests are presented in the following table:

Thermocouple Type	Temperature Rise - °F Time After Heat Application 1 sec	2 sec	3 sec
1 Welded bare wire	120-150	435-490	825-885
2 Welded sheath contact	15- 22	135-150	340-375
3 Spring load, hemisphere tip (as received)	15- 22	60-105	160-220
4 Spring load, 0.047" flat tip*	30- 38 (15)	135-165 (100)	270-315 (220)
5 Spring load, copper cap	15- 22	90-135	285-320
6 Spring load, bronze cap	8- 22	45-135	130-270
7 Spring load, SS tip, 0.090" dia.	15- 30	120-150	290-360
8 Spring load, silver tip,* 0.085" dia.	45- 90 (25)	180-300 (210)	360-570 (420)

*Parentheses indicate results with the thermocouple assembly electrically insulated from the test heater.

Thermocouples types 1 and 2 are described above. The welded sheath contact only gave about one-third of the response of the bare thermocouple. Type 3 consisted of spring pressure contact of a normal sheathed thermocouple perpendicular to the test heater. The normal sheathed thermocouple has a hemispherical tip. This would tend to give slow response because of the small contact area and because of the sheath tip being thicker than the normal sheath wall. The temperature response was less than one-fourth that of the bare thermocouple.

By use of a file to remove part of the thick hemispherical sheath tip and produce a flat surface about 0.040-inch in diameter, the response of the sheathed thermocouple was improved considerably as shown for the type 4 assembly.

Type 5 thermocouple utilized a copper disc about 0.1-inch diameter by 0.040-inch thick. One side of the disc was indented to fit the hemispherical tip of an "as-received" sheathed thermocouple. This arrangement allowed the disc to pivot and retain good contact with the test heater when it bowed during a heating cycle. The copper cap provided only slightly better temperature response than the "flat tip" (No. 4) after three seconds of elapsed time and less favorable response at shorter times.

Type 6 employed a bronze cap somewhat similar to the copper cap except that a sleeve of the cap fitted over the thermocouple to provide rigid support between the two. The response of this assembly was less favorable than the copper cap, probably because of the added heat sink of the sleeve and generally poorer contact area during heater distortion.

Types 7 and 8 thermocouples were similar to each other in that a ball or drop of metal (stainless steel or silver solder) was melted onto the tip of the "as-received" thermocouple. The tip was then ground back (in a plane perpendicular to the sheath axis). The intent of the grinding was to remove most of the hemispherical tip of the sheath. This was inspected by visual means in the case of the silver solder tip but was only controlled by scribe marks on the sheath for the stainless steel tip. From the above table, it is apparent that the silver tip assembly is the best assembly of the sheathed thermocouples which were tested. The response of the silver tip assembly is better than that of the welded sheath contact assembly (Type 2) even when the silver tip was electrically insulated from the heater surface by a thin ($\approx$ 0.001 inch) mica flake, as indicated by numbers in parentheses.

While the absolute accuracy of the above tests is open to question, the comparative results show that a spring loaded silver tip thermocouple will respond to a transient temperature change as well or better than a welded sheathed contact thermocouple assembly. However, the reproducibility of the welded contact was better than the spring loaded contacts in these tests, probably because of test section distortion during transient heating.

J W Albaugh

Manager, Reactor & Fuels Laboratory

PHYSICS AND INSTRUMENTS LABORATORY

MONTHLY REPORT

AUGUST 1964

FISSIONABLE MATERIALS - 02 PROGRAM

REACTOR

N-Reactor Lattice Parameter and Spectral Measurements at Startup

The data from the January and April irradiations are being prepared for documentation. Graphs and tables of detector positions and activities, detector compositions, conditions during irradiation and the γ-ray counting, are being assembled. Some difficulties have been encountered in the calculation of cadmium ratios. During irradiation the bare pins were located some distance from the cadmium covered pins. Hence, some normalization between the positions is necessary to compensate for the differences in neutron flux. Graphs of the axial flux variation during both irradiations have been obtained from N-Reactor Department. These graphs together with the experimental data are being studied to determine a method for normalization.

Utilization of Plutonium Fuel

PCTR experiments in support of the safety of reactors fueled with Pu-Al with high I&E geometry are being planned. In support of these experiments, calculations are under way to determine k_∞ for a range of Pu-Al concentrations and compositions. To date, PHYSICS CHAIN calculations have been carried out for four cases, 1.8 and 2.2 w/o L_X Pu-Al, and 1.8 and 2.2 w/o H_X Pu-Al. The resulting k_∞ values are 1.426 and 1.485 for the L_X, and 1.307 and 1.368 for the H_X.

NPR Utilization Studies

Work on the physics of fuel cycle analysis for Phase III operation (power only) at the NPR is continuing. All of the planned burnup calculations are completed for both the ThO_2 and UO_2 cycles. Temperature effect, spectral interaction, and control rod worth calculations have been started.

Instrumentation

One hybrid (transistor and vacuum tube) preamplifier was completed for use with the N Reactor subcritical neutron monitor and tests were conducted with it and with the modified main chassis at the 305 Reactor. The preamplifier was then installed at N Reactor in readiness for the forthcoming startup. Some transient noise problems remain to be resolved; however, they are less troublesome than had been anticipated.

Two more preamplifiers are being fabricated and further temperature tests will be conducted to ascertain their high temperature performance. Considerable circuit improvement will be necessary on the monitor main chassis. Two neutron fission counters were tested and one was delivered to N Reactor for installation; the other was retained for further tests.

System Studies

N Reactor simulation runs were made at full power level to determine the maximum change which might occur in the steam generator level and pressure setpoints assuming an undrained surge tank. The studies also elucidated the effect of adding a 10 psi drop in the surge tank line connected to the condensate header. Data are being analyzed.

Recordings of the N Reactor Bailey meter controller inputs and outputs during a scram are useful in updating the N Reactor analog simulation. A special delay circuit was constructed to enable the recordings to be made without an operator being present. The circuit is actuated by the reactor safety circuit such that a scram energizes the recorder for a minimum period of 0.5 to 15 minutes.

In-place calibration of N Reactor controller units has been found to be unsatisfactory because of difficulty in controlling and isolating input voltages. The possibility of using a portable rack for testing and calibrating these units is being considered by N Reactor personnel.

The effect of a 10 psi pressure drop on a nominal flow of 5000 gallons per minute through the surge tank outflow line was programmed in the N Reactor simulation. Results are being evaluated.

SEPARATIONS

Critical Experiments with Plutonium Solutions

Further criticality studies were performed with $Pu(NO_3)_4$ solutions in a 15.2-in. diameter (30.2 liter) thin walled (48 mils) stainless steel sphere.

The data obtained permit evaluating the effect of nitrate on criticality in the unreflected sphere. The nitrate in the Pu solution has a pronounced effect on criticality as shown below.

Criticality in 15.2-in. Stainless Steel Sphere

Critical Pu Conc.	Acid Molarity	Total Nitrate	H/Pu Atomic Ratio	Critical Volume	Critical Mass
(39 g Pu/ℓ)	(0.4)	(64 g/ℓ)	(662)	(30.2)	(1.18 Kg)*
172 g Pu/ℓ	4.9	486 g/ℓ	125	30.2	5.20 Kg*

* Pu^{240} content is 4.6 w/o.

A variation in nitrate concentration from 64-486 g/ℓ resulted in the critical concentration and critical mass being increased by a factor of ~4.4. The values shown in parentheses were determined the previous month. Since there is a paucity of data on unreflected Pu solution spheres, these results will be particularly useful for checking theory.

Few criticality data exist for evaluating the effect on criticality of an air gap between a reactor core and its reflector. A reflector is most effective when in contact with the core, but a small air gap can strongly reduce the effectiveness of a reflector. During the month, additional data were obtained for evaluating the effects of air gaps on criticality. In these measurements, the 15.2-in. diameter sphere was reflected with a 6-in. thick concrete shell, but with an air gap of 3 5/8-in. between the vessel and reflector. Foil irradiations were also made for determining the neutron flux distribution and the extrapolation length appropriate to the concrete reflector with the air gap.

On completion of these experiments, the concrete reflector shell was removed and critical mass measurements were begun with the 15.2-in. sphere fully reflected with water. In addition to the measured critical masses, gold and copper foils, shielded with boron solutions of different concentrations, are being irradiated for determining the neutron energy spectrum within the critical sphere.

Pulsed Neutron Source Experiments

Potentially, the pulsed neutron source technique may have wide applicability in assessing the degree of subcriticality of process vessels and storage arrays of fissile materials in the plant. Fundamental data for

determining the validity of such measurements on large systems were obtained during the month when pulsed neutron source experiments were performed in an "infinite" water tank in the 300 Area. A mathematical model has been developed which defines the thermal neutron distribution as a function of time and distance between source and detector following a pulse of neutrons. The purpose of the experiments was to examine the time required to establish the asymptotic form of the neutron decay in an infinite system as a function of distance between the neutron generator and the detector. The neutron lifetime in the water was measured as $\sim 200 \pm 5$ μ sec. which is in agreement with previous measurements.

Pulsed neutron source measurements have been made in conjunction with the approaches-to-criticality in the unreflected 15.2-in. diameter sphere. The results of the data analyses are given in the table below for the full sphere (30.2ℓ volume).

Neutron Lifetime and Prompt Criticality in 15.2-in. Sphere

Experiment Number	Prompt Critical Volume (Liters)	Neutron Lifetime, μ sec. (β = 0.0021)	Pu Conc. (g/ℓ)	H/Pu Atomic Ratio	NO_3 (g/ℓ)
1-15.2-1258	30.382 ± 0.004	25	39	662	64
1-15.2-1287	30.351 ± 0.002	6	173	125	483

The difference between delayed criticality and prompt criticality in the full 15.2-in. sphere (30ℓ) is thus ~0.17 liters, which amounts to about 0.6 percent in excess mass above delayed criticality.

Reactor Noise and Reactivity Measurements

Measurements were made of reactor noise to corroborate a theoretical prediction that subcriticality of a reactor could be determined independently of a knowledge of kinetic parameters such as the prompt neutron lifetime and delayed neutron fraction. The method involves an analysis of the relative magnitude of the reactor noise power density spectrum at two frequencies, one of which is chosen to include delayed neutron effects and one of which is dominated by prompt neutron effects.

The measurements consisted of five recordings of reactor noise in bare, subcritical, spherical Pu solution systems, for five different cases of subcriticality. Each recording was made for three hours and twenty minutes. Subsequent re-recordings were made so that a frequency increase by a factor of 1024 was effected between real frequency and analysis frequency.

The preliminary results showed qualitative agreement between theory and experiment for the range of frequencies studied. It was not possible, however, to make a quantitative study because of frequency limitation (it appears that one must measure to at least 0.01 radians/sec.) and because of the limitations imposed by further noise being introduced in subsequent re-recordings.

Theory and Methods of Computing Criticality Parameters

A difficult technical problem of importance in processing reactor fuels involves criticality of U rods in U solution (problem of uranium dissolution). A three-region lattice Monte Carlo code has been written to obtain data for nuclear safety guidance. Solution of this kind of problem moved a step closer during the month with the successful application of the Monte Carlo code to data on uranium-water lattices as a first check on the method.

TRUNK is a code which may be used to calculate the geometric buckling of bare, partially filled spheres. Previously, the second derivatives of the flux calculated near the top surface of the truncated sphere changed signs--an impossible physical result. This result came about by a poor approximation to the Laplacian at the top surface, where the nine point grid does not match the flat boundary. A new approximation which is more promising has been made. It consists of using the analytic nine point flux approximation with the proper boundary conditions included and differentiating it analytically to obtain ∇^2. Tests of this method of approximating ∇^2 for an arbitrary analytic function matching the boundary conditions showed errors of the order of 0.1%, which is within the limits of the desired accuracy.

The job now must be chain-linked into three pieces to allow the very complex functions to be evaluated in double precision arithmetic. Debugging on this procedure is in progress.

The following are major improvements to INTERSET (cylindrical interaction code):

1. A multi-group, multi-region, one-dimensional cylindrical diffusion calculation is being substituted for the present age diffusion calculation in computing the system k. This calculation, a simplification of HFN, treats cylinders with several homogeneous regions and uses a full scattering matrix.

2. Changes to allow cylinders of different diameters have been completed. Previously each unit was required to have the same diameter.

3. The primary integration routine for cylinder-to-cylinder interaction has been modified to use Simpson's Rule rather than the trapezoidal rule integration. The loss in accuracy is only 1/20%, but the time for a single calculation is now one-half second as opposed to the 30 seconds required previously. Average cases now run in one rather than fifteen minutes.

4. The shielding of neutron flow between two units by an intervening unit is being revamped to give a more accurate approximation. Previous use of area ratios gave ± 20% accuracy, while the new method of computing the shadowing integral directly gives ± 5% accuracy in this calculation.

Critical Mass Laboratory Instrumentation

A method for routinely measuring the time response of the control and safety rods for both solid and solution assemblies at the Critical Mass Laboratory has been devised. This method will enable the operators to time the scramming operation of the rods prior to an experiment and thereby routinely determine that the insertion time of the rods remains as designed. The existing Erie model 400 counter-timer will be used for this measurement. It is capable of measuring intervals down to 10^{-5} seconds. Installation of the circuitry is now in progress.

The construction of the readout selector for the on-line noise analysis system is 80% complete. Included in the readout will be provisions for manual, slow, and fast scanning of the 40 outputs of the noise spectrum analyzer. Frequency markers for the fast scan and channel identification for the slow scan will be provided.

Consulting Services on Nuclear Safety--Criticality Hazards

1. Nuclear Safety in HL

New nuclear safety specifications and changes in existing specifications were reviewed as follows:

a) Temporary Specification No. 5 for Technical Shops Operation, covering 1.95 w/o U^{235} enriched uranium N-fuel, was issued.

b) Specification B-8 for Experimental Reactors Operation, covering 35 w/o U^{235} enriched U-Al alloy, was revised.

2. Nuclear Safety in CPD

A hazards review was completed of the miscellaneous treatment facility in 234-5 Building for Facilities Engineering. Document HW-83641 was issued covering this review.

3. Nuclear Safety in NRD

The nuclear safety review of the 333 Building for processing 1.95 w/o U^{235} enriched uranium fuels was completed for N-Fuels Engineering. The N.S. specifications were subsequently approved and issued.

Plans have been formulated for performing a series of exponential experiments on 1.25 w/o and 1.95 w/o U^{235} enriched N-fuels in support of nuclear safety calculations. The measurements which are scheduled to begin in September will provide data on the material bucklings of the enriched fuel elements in water, from which the critical volumes and masses may then be derived.

4. Nuclear Safety in Shipment of Fissionable Material

Shipment of 1500 fuel rods (1.5 w/o PuO_2-UO_2) to ANL was reviewed and approved. This was a Class III shipment on an exclusive use railway car.

Separations Instrumentation and System Studies

Four Pu-239 sample solutions were obtained for use in calibrating the 17 keV X-ray liquid sample counting system recently installed in the 234-5 Building. Calibration tests were started following completion of the preamplifier and multiplier phototube socket wiring.

Development work was initiated with various multiplier phototubes and crystals for the plutonium waste carton monitoring system. The monitor will be used to measure the amounts of plutonium contained in CPD waste cartons.

METALLURGY - Nondestructive Testing

N Fuels Testing

1. Fuel Element Testing - End Closure

The feasibility of modifying the end closure test to permit the measurement of cap thickness is being reviewed. There is some probability

that some fuel element end caps could be machined down to half or even to almost 100% of the cap thickness due to errors in the fabrication process. The investigation consists of three phases:

a. A cap thickness test using UT-9 hardware with modifications.
b. Incorporation of additional hardware into the UT-9 system.
3. A completely portable test instrument.

Preliminary correlation effort has produced encouraging results. Several samples were inspected with a 15 megacycle ultrasonic system and the results were correlated within 10 mils of the actual thickness (180 to 260 mils). The test measures the lapsed time of the signal from the end of the cap to the cap core interface.

The use of a portable system and one utilizing existing UT-9 hardware present problems. The amount of modification necessary for existing instrumentation to perform this added function needs to be determined. The degree of portability, economy of design and reliability also needs to be determined for a new portable tester.

The cap-to-core bonding test is being reviewed. The effort thus far has been limited to evaluation of test standards by use of a wide band system and point focused transducers.

2. Fuel Element Testing - Clad Thinning

Abnormal thinning caused by abrasion on the inner clad of the inner N fuel element over the region of the braze closure is called "dog bone" thinning. A nondestructive test is needed to detect this condition even though it can be controlled through process control techniques. Standard ultrasonic techniques cannot be applied successfully because the interfaces involved are of the same general materials and therefore have similar ultrasonic reflectivity.

The application of boundary waves is being investigated as a possible ultrasonic method for detecting this thin clad condition. Some preliminary work with boundary waves on two fuel sections having known clad thickness differences has been encouraging. A small probe is being designed to enable inspection of the regions involved.

3. Target Element Bond Test

The target fuel element is a lithium aluminum core clad with aluminum by a coextrusion process. A nondestructive test is desirable for inspecting the target element for bonding of the clad core. In this

case, an unbond is the desirable condition due to possibility of the diffusion of lithium into the can from the core. Therefore, the test must be able to detect bonded conditions as differentiated from unbonded.

The test technique developed is a pulse echo test using the back reflection signal as the indicator of bond condition. If a lack of bonding exists the 2-1/4 megacycle pulse energy does not return at the predetermined time period and no output is recorded. If a region of bonding occurs, an echo signal is present during the proper time period and the output is recorded on a pulse counter. Prototype hardware has been readied for installation in the 306 pilot plant to further evaluate this technique on larger numbers of fuels.

4. Fuel Element Testing - Bond Test

An alternate method of detecting unbonds on the i.d. of N fuel elements has been successful in the laboratory. The testing technique involves the outside-in technique of examining the i.d. interface by passing the ultrasonic pulse through the outer jacket and the uranium core. The technique is similar to a method which has been successfully demonstrated on the AlSi fuel. This approach will be useful in evaluating existing bond testing hardware and will aid in the evaluation of test standards.

5. X-Ray Fluorescence Test Development

The X-ray fluorescence tester has been updated by the installation of the new dual strip chart recorder. Assistance in the maintenance problem on the X-ray unit showed that one of the high voltage electron tubes failed due to an open filament. Other assistance was given N Fuels Quality Control in preparing calibration standards and evaluating the equipment. The operational manual for the tester is approximately 90% complete.

6. Fuel Element Uranium Contamination Testers

Fabrication of the third generation alpha counter for measurement of uranium contamination on N fuels is proceeding on schedule. Electronic instrumentation is in the final stage in the Technical Shop, and work on the mechanical design is about 50% complete.

7. Inner Fuel Element Cap Crack Testing

Cracked end caps appear to be reducing the integrity of N fuel elements.

The cracks are believed to occur during extrusion of the bar stock from which the caps are fabricated. Investigation of this problem included inspection of bar stock ultrasonically, ultrasonic inspection of machined caps, and a preliminary approach to testing of caps on completed fuel elements. Results were highly encouraging for most all aspects. Cracks in the extruded bar stock samples were detected using an angled beam pulse echo, immersed, test. Results showed that defective bar stock could be readily detected and that the test would be amenable to use in the vendor's plant. Tests also revealed that cracks in sample caps could be detected with special techniques. A two transducer arrangement appears most favorable for routine use in the fuel manufacturing facility. It appears that similar techniques can be used to detect cracks in the caps of finished fuel elements. Results of the investigation are documented in TM Memo 64-14.

8. Irradiated Fuel Testing

Post irradiation testing of inner N fuels was completed using the UT-10 station in 105-KE basin. No additional flaws were found. Out of a total of 71 inner fuels tested, 6 fuels with core cracks were found. No other flaws of any significance were found in testing the inner fuels. A thorough visual examination of the outer tube having suspected blisters at one end of the inner surface was completed by radiometallurgy. No blisters were seen; however, a surface depression assumed from the rail of the inner tube was at the approximate location of the suspected blisters. A summary of the findings from testing of all of the 144 irradiated fuels was written.

AlSi Fuel Testing - Bond Test Development

The new bond test development for use on testing of the inner bond of the AlSi fuel element was evaluated on the MERCY program. Results of the analysis of the data indicate a very substantial improvement in the tester precision and tester bias when compared to the existing internal bond test equipment. A conservative estimate of the tester's production line capability places it in the same category as the existing external bond test. It has been shown that this capability is sufficient to satisfy all the tester requirements.

Further work on this program includes some correlation work to determine the tester capability in concurrently detecting external unbonds with the same test setup. Development of highly reliable prototype equipment of a complete internal bond tester has been started. Work is now proceeding on a Nuvistor wide band amplifier for use in this system. The aim of this program is to produce an ultra reliable, maintenance free, electronic unit

for use in this test system.

Chemical Processing Department - Resin Level Detector

The resin level measuring detection used in the CPD columns uses low frequency ultrasonic transducers. Problems with these transducers have instigated an investigation into more reliable transducer assemblies which will operate well in this corrosive environment and also reduce the problem of bubbles in the solution. Four new transducer assemblies were completed and delivered to the 200 Area Instrument Shop. Two of the new transducers were equipped with glass faces and wire mesh bubble deflectors. They have not been used in the process as yet so their effectiveness in the bubble generating solution remains to be seen. Laboratory tests have confirmed the screens' effectiveness toward reflecting large bubbles, but have cast some doubt on their ability to eliminate problems from smaller bubbles, particularly those which approach the size of the mesh openings.

A circuit was devised to eliminate problems on the meter reading when no resin echo is present. The circuit was installed in one of the two testers for evaluation which will give a zero reading when no resin is present.

NEUTRON CROSS SECTION PROGRAM

Triple-Axis Spectrometer

The alignment work on the triple-axis spectrometer has been completed. A study has been made of the neutron reflectivity characteristics of the families of Be($10\bar{1}1$) and Be ($10\bar{1}3$) crystal planes under varying conditions of angular collimation. The results of this study indicated that a Be($10\bar{1}1$) plane with collimation appropriate to a particular measurement was the best configuration for the analyzing spectrometer. Using this configuration measurements were resumed on the scattering law for polystyrene. Significant scattering was observed for neutron energy losses of 0.05 - 0.16-eV. Within the rather poor statistical precision of the data no scattering to discrete levels could be identified with an energy resolution of about 0.02 eV.

Time-of-Flight Spectroscopy for Slow Neutrons

The major components of the developmental spectrometer for slow-neutron inelastic scattering by time-of-flight were assembled for use at the 4-B hole of 105-KE. The spectrometer was put into test operation during the month. Preliminary experiments were performed to determine the operating characteristics of the system. These experiments included the measurement

of the time width and energy width of the pulsed neutron beam from a rotating diffraction crystal of aluminum. The various resolution components derived from these measurements compared favorably with calculated values. Measurements were made both with the mechanical chopper open and rotating in phase with the crystal monochromator. The latter measurements showed that the chopper was not sufficiently effective in removing second order neutrons of the Al(220) reflection or the Al(240) reflection. A higher collimation slit system for the chopper is being fabricated to improve this characteristic. A survey measurement was made of the scattering from vanadium using nine scattering angles from 15 to 135 degrees. Minor modifications to the system are being made during a reactor outage.

Fast-Neutron Cross Sections

Analysis of previously obtained 3 to 15 MeV total cross section data has continued. The computer program LIL NED was used to evaluate final data on the measurements for Pm^{147}. An invited paper was prepared on intermediate structure in fast-neutron cross sections for presentation at the Gordon Research Conference.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Reactivity Effects Due to Pu Lumping in PuO_2-UO_2 Fuel Rods

A short survey study of the reactivity effects of plutonium agglomeration of fuel components in mixed oxide, PuO_2-UO_2, fuel rods has been completed. The study was performed for rods consisting of 2 w/o Pu, natural U mixed oxide rods in light water. The lattice chosen for the study was hexagonal with a pitch of 0.71 inch. The length of the fuel was assumed to be four feet.

Values of the effective multiplication factor, k_{eff}, were calculated using HFN for three temperatures, three Pu-240 concentrations, and three particle sizes. Four-group cross sections for use in HFN were generated using THERMOS, TEMPEST, and HRG. Details of the calculational method have been described previously. Doppler-broadened Pu-240 cross sections were obtained from the GROUSS code. Shielding in the Pu lumps was accounted for by calculating escape probabilities, $P_c(E)$, assuming the lumps were spherical in shape. These factors were used to weight the cross sections used in THERMOS.

The effect of lumping is -3 to -7 milli-k for 50 micron particles and -6 to -14 milli-k for 100 micron particles. If the agglomerated particles diffuse as the fuel is heated up in an operating reactor and the fuel

becomes homogeneous, then for the fuel and conditions of the present study, a gain of up to 1.5% in k_{eff} would be expected from this phenomenon.

The total temperature coefficient tends to be slightly smaller with increasing particle size. The reactivity change due to increasing temperature is less negative for higher Pu-240 concentrations. This is due to a decrease in the Pu-239 density as the density of Pu-240 was increased in the calculations.

PRTR Burnup Experiments

Calculations are now being made to compare with the H_x-Pu-Al burnup data and the UO_2 burnup data. The codes THERMOS and ALTHAEA are presently being used. The input parameters for the zero-dimensional burnup code ALTHAEA are determined using THERMOS.

Of particular interest is the UO_2 burnup data from element 1501. The element is a nested, tubular fuel element. Its cylindrical geometry can be put directly into THERMOS, whereas, an equivalent cell is being used for all 19 rod clustered elements.

A total of 18 mixed oxide fuel samples have been dissolved and the initial data, sample weights, Cs-137 counts (d/m/ml), and Pu alpha counts (d/m/ml), have been received.

Code Development - HRG

Recent revisions in HRG have been completed and a version of the PHYSICS CHAIN tape with HRG replacing GAM is now available. Binary decks of the revised HRG have also been distributed to several Hanford Laboratories users. Any holders of decks of earlier versions should arrange for their replacement by the authors.

Because of limitations in the SIGMA-3H link, the PHYSICS CHAIN version of HRG can presently use only those nuclides corresponding to GAM nuclides. Revisions in the SIGMA-3H library are currently being made to remove this restriction.

Phoenix Fuel Program

1. MTR Plutonium Loading Analysis

Idealized MTR-type cores, combining various plutonium loadings, isotopic compositions, metal-to-water ratios, and plate designs, are being examined in reactor multiplication and burnup calculations. This

survey is aimed at providing information to be used in identifying a feasible Phoenix fuel burnup experiment, possibly using the MTR as the test bed. Limitations due to thermal-hydraulics, heat transfer, and fuel integrity are being studied by other groups in Hanford Laboratories.

To check the validity of the survey calculations, one-dimensional slab models have been utilized for multiplication and burnup calculations (ZODIAC) of the MTR Cycle 108 plutonium cores. A simple volume-homogenization of the core components and the reflector parts was the basis of a materials specification. The computations were made more reliable, however, by using flux depression factors from THERMOS cell calculations and by using buckling values derived from previous two-dimensional studies using ANGLE. If a correction in η (to agree with Sher data) is applied, the one-dimensional model yielded initial multiplications which agree with experiment to within 1% $\Delta k/k$.

2. Zirconium Hydride Study

SPECTRUM calculations have been completed for the regions of TRIGA at temperatures of 293, 533, and 693 K. Two sets of calculations were carried out. One set treats all the hydrogen with the water kernel, and the other set treats all the hydrogen with the zirconium hydride kernel. TEMPEST and GAM have been run and the HFN input data are being prepared for the final step of the calculations for the TRIGA core.

will be expanded to consider the effects of Cm-242, Cm-243, and Cm-244.

4. Pu-Al Light Water Experiments in the PCTR

The reactivity worths in the PCTR of about 40 of the PPA fuel disks have been compared to that of uranium foil. The mass of uranium per disk was found to vary from about 2.0 grams to about 2.7 grams. This variation is partially due to differences in disk thickness, but there is also a significant variation in uranium concentration. A procedure is now being devised to select disks containing approximately the same amount of uranium for the buffer fuel without measuring their reactivity worths.

Bids have been received for 10,000 polyethylene disks to contain one percent boron; however, the borated disks from the PPA will initially be used in the U-Al experiment.

Isotopic Analysis of PRTR Samples

Isotopic analyses were provided on 14 plutonium and 9 uranium samples of PRTR-irradiated fuel elements in support of the Plutonium Recycle Program. All of these were burnup samples from Al-Ni-Pu element Number 5187.

Instrumentation and System Studies

Multiplier phototube testing for the PRTR fuel rupture monitor was completed. Results indicate that the EMI 9536-B, EMI 9524-B, and Amperex XP-1010 tubes are superior in stability characteristics to the RCA 6199 tubes now in use in the monitor. Testing showed that the gain instability of these tubes is primarily due to increased operating temperatures, although excessive counting rates are also believed to be a contributing factor. It was concluded that performance of the fuel rupture monitor could be materially improved by thermally insulating the detectors and reducing the counting rate through the use of shielding. A detailed report was prepared.

Specifications were prepared for new recorders and scanner relays for the fuel rupture monitor. A prototype six-point scanner was designed for experimental use. The recorders will permit scanning the output signals from 17 detectors, where each detector monitors gas from five process tubes.

Design was nearly completed on a detector assembly using a lead-shielded (with collimator hole) small solid state alpha detector and a regular machine-type dividing head for use in delineating the migration of plutonium

in sections of experimental fuel elements. Fabrication of the detector assembly was initiated.

A rough draft of the PRTR automatic controller test was written, exclusive of detailed test procedure. The test was proposed to allow evaluation of the PRTR automatic controller in the period mode of operation without taking the reactor critical. The reactor will be simulated during the test by an analog computer located in the 3707-C Building. The necessary signals will be transmitted between the PRTR and the analog computer facilities.

EBWR EXPERIMENT PROGRAM

The effective multiplications for the mixed oxide zone alone and the whole core (PuO_2-UO_2, enriched UO_2, natural UO_2, and reflector) have been calculated for various moderator temperatures, void fractions, and boric acid contents. The calculations employed few group parameters from THERMOS, GAM-1, and TEMPEST in HFN. Few-group parameters from HRG were also used to calculate k_{eff} of the cold clean core and compared to the results using GAM-1. The calculated k_{eff} was approximately one percent higher using HRG. The moderator temperature coefficient, Doppler coefficient, and void coefficient are negative for both the mixed oxide zone and the whole core. The amount of boric acid needed to poison the mixed oxide zone, and also the whole core to an effective multiplication of 1.0 with moderator either cold or hot has also been determined.

Experiments

1. Measurements of β/ℓ

   A recording of reactor noise was retaken with PuO_2-UO_2 fuel loaded in the PRCF and moderated by H_2O. The ratio of signal to extraneous noise from this recording is considerably higher than that from the recording of a previous experiment. A recording of a white noise source was taken to determine the characteristic of the data acquisition and data analyzing equipment. The data have been analyzed but need further work in order to deduce β/ℓ.

   The analysis of the kinetics experiment using a boron arrow is nearly complete. Three distinct groups of neutrons can be resolved from the first two seconds of decay after poison is injected into the reactor core. The β/ℓ ratio obtained from the shortest lived of these is 83.3.

2. Temperature Coefficient

The H_2O moderator temperature has been changed from 20°C to 72°C. The temperature coefficient changes continuously from +0.025 mk/°C at 20°C to 0 at 28°C to -0.045 mk/°C at 72°C. The scatter of points on the curve plotted from the temperature coefficient vs. temperature data indicates a statistical error of ±0.007 mk. An attempt to measure the temperature coefficient up to 90°C is being made.

3. Spectrum Measurements

A vertical traverse using Au and Pd foils was made near the center of the EBWR 0.71" core. Each of three pairs of foils was placed in radially symmetric positions. The separation was used to minimize the effects of cadmium covers. A similar normalizing irradiation using Au and Pd foils on a rotator was made in the center of the TTR core where the neutron flux is well known. All Au and Pd foils in both irradiations were exposed under 0.040" cadmium. The results of this experiment will be used to determine the 1/E spectrum. Counting of the foils from both irradiations is completed.

One of the Pd foils irradiated under cadmium in the PRCF was counted to obtain a decay curve. The desired 13.6 hour activity of Pd-109 can be obtained after eight hours decay of the short-lived activities. The 17-day activity of Pd-103 was less than 0.5% of the counting rate up to 30 hours decay time.

A copper wire was irradiated under cadmium in the EBWR 0.71" core. This completes the measurement of the radial cadmium ratio. The copper has been counted, but none of the data have been analyzed.

The cadmium covered lutetium vertical and radial traverse on the fuel and the cell traverse have been irradiated and counted. The analyses of the lutetium data are about 50% completed.

4. Irradiation and Perturbation Measurements

A radial traverse with a solid copper rod and vertical traverses using a poison sample and a sample of fissionable material have been completed. The reactivity effect of a Zircaloy-2 tube, 7-1/2" in length and 2" in diameter (encircling 7 fuel rods) was measured in the center of the PRCF at three vertical positions. The worth of a 1.8 w/o Pu-Al fuel rod was measured in the center of the reactor. Moderator worth and reactivity coefficient measurements were extended down to a moderator level of 85.48 inches.

HIGH TEMPERATURE REACTOR PHYSICS PROGRAM

A worst-case estimate of graphite corrosion in HTLTR was made using data gathered in the last few months on the outgassing properties of insulating materials. This estimate showed that the diatomaceous earth thermal insulation which had been specified should not be used. The most undesirable property of diatomaceous earth is reabsorption of water after it has been outgassed. Water that the diatomaceous earth reabsorbs from the atmosphere can be driven off again only if the temperature is raised so high that there would be danger of the effluent steam reacting with graphite. Fibrefrax appears to be the best substitute for diatomaceous earth, although Tipersul is also being tested. So far, tests show that Fibrefrax gives off much less gas than Tipersul but it remains to be seen how corrosive the gases are and which of the two materials will reabsorb the most.

Other ways to reduce graphite corrosion were suggested and the architect-engineer is incorporating these suggestions in the reactor design where feasible. For example, reduction of the relative humidity of the reactor room will keep reactor materials from reabsorbing water from the air; and redirection of the gas flow and provision of variable purge rates can help minimize corrosion. Work will continue on the graphite corrosion problem particularly on carbon transport caused by the reactions $2\ CO \rightarrow CO_2 + C$ in the cold part of the gas system. When this reaction occurs in a recirculating system, free carbon is plated out. The CO_2 formed then continues around the loop to the hot graphite stack where it reacts with graphite to form more CO.

Compatibility tests run this month showed that the alumina brick specified for insulation next to the graphite stack does not catalyze the oxidation of graphite. A test was tried with particles of brick on the graphite at different temperatures and another test was tried with a brick surface against the graphite. If anything, the brick slowed the oxidation of the graphite in both tests.

More compatibility tests have been set up to check reactions between materials that have survived survey tests and are likely to be used in the reactor. These materials include TD nickel, a matrix poison material containing graphite, and B_4C and the alumina brick. In addition, some samples of a UO_2-graphite matrix fuel material made by the Advanced Fuels Development Operation will be tested for compatibility with TD nickel, the matrix poison material and graphite. The matrix fuel material contains 3 gms/cm3 of UO_2, and has good structural integrity at room temperature. It machines like graphite. Advanced Fuels Development Operation is proceeding to make full size pieces of the fuel matrix material for testing in a mockup of the horizontal control rods.

FUEL CYCLE ANALYSIS

(This section was formerly reported by the Programming Operation)

Resonance Interference in ALTHAEA

The capture-to-fission ratio (alpha) of Pu^{239} is unfavorable in the resonance at 0.3 eV. The reaction rate due to this resonance is reduced if other isotopes are present which compete for neutrons of that energy thus reducing over-all effective alpha. Preliminary estimates of resonance interference or cross-shielding of the resonances at energies less than one electron volt have been placed on a cross section data tape for ALTHAEA-MELEAGER to reflect this effect. The degree of interference was estimated and is presented in Table I. Since the resonances at higher energy do not, in general, interfere to the same degree as these low energy resonances, an estimate of the portion of the resonance integral not subject to cross-shielding was also made. These estimates are presented in Table II. The variation in the calculated alpha value is presented in Table III. This variation is sufficient at the higher concentrations to warrant refinement of these estimated interference coefficients by more rigorous means, such as a Monte Carlo perturbation analysis.

TABLE I

CROSS-SHIELDING FACTORS FOR ALTHAEA

Shielded Isotope	Shielding Isotope				
	U^{235}	Np^{237}	Pu^{239}	Pu^{241}	Am^{241}
U^{235}		.0	.75	.70	.40
Np^{237}	.0		.0	.0	.30
Pu^{239}	1.3	.0		1.1	.60
Pu^{241}	1.2	.0	.90		.50
Am^{241}	2.5	.02	1.6	.70	

TABLE II

FRACTION OF RESONANCE INTEGRAL NOT CROSS-SHIELDED

Isotope	Noncross-shielded Resonance Integral
U^{235}	.75
Np^{237}	.80
Pu^{239}	.40
Pu^{241}	.50
Am^{241}	.60

TABLE III

INFLUENCE OF CROSS-SHIELDING

Cross-Shielding	Percent Enrichment (1)	Neutron Temperature (2)	Spectral Index, r	Alpha U^{235}	Alpha Pu^{239}	Alpha Pu^{241}
No	1.0	293	.100	.204	.515	.310
Yes	1.0	293	.099	.204	.508	.312
No	2.0	311	.235	.249	.545	.310
Yes	2.0	313	.221	.240	.522	.313
No	3.0	326	.347	.285	.565	.310
Yes	3.0	332	.317	.266	.537	.314

(1) U^{235} enrichment of 0.83% plus plutonium (76% Pu^{239}, 18% Pu^{240}, 5% Pu^{241}, 1% Pu^{242}).

(2) Based on 263°C moderator temperature.

Pu^{238} Indifference Prices for Production via Americium^{241} Target Irradiation

If plutonium is stored out-of-reactor, the Pu^{241} will decay (β) forming Am^{241} which can be irradiated as a target material. The Am^{241} absorbs a neutron resulting in Cm^{242} formation which has a 63-day half life decaying by alpha emission to Pu^{238}. If the major part of the Cm^{242} decay takes place out-of-reactor, the Pu^{238} will be very pure (greater than 90%) but if most of the Pu^{238} is formed in the reactor flux, Pu^{239} will be formed and the purity of Pu^{238} will be reduced.

$$Pu^{241} \xrightarrow{\beta^-} Am^{241} \xrightarrow{n} Cm^{242} \xrightarrow{\alpha} Pu^{238} \xrightarrow{n} Pu^{239}$$

To determine the relative isotope values, burn up calculations were made for various Am^{241} target sizes and irradiation times in a simulated pressurized water reactor using the MELEAGER burnup code. The QUICK Economics code was used to calculate minimum fuel cost for each target situation and a range of isotope prices. The indifference price was found by determining the price for Pu^{238} that must be paid for a given Am^{241} price so that the fuel cost will be the same as when the target is not present. Figure 1 shows the price which must be paid for Pu^{238} as a function of Am^{241} price. These prices do not include the extra cost of special isotope (Cm^{242}) recovery. This cost should be added to the price indicated on Figure 1.

INDIFFERENCE PRICE FOR PLUTONIUM^{238}

AS A FUNCTION OF AMERICIUM^{241} PRICE

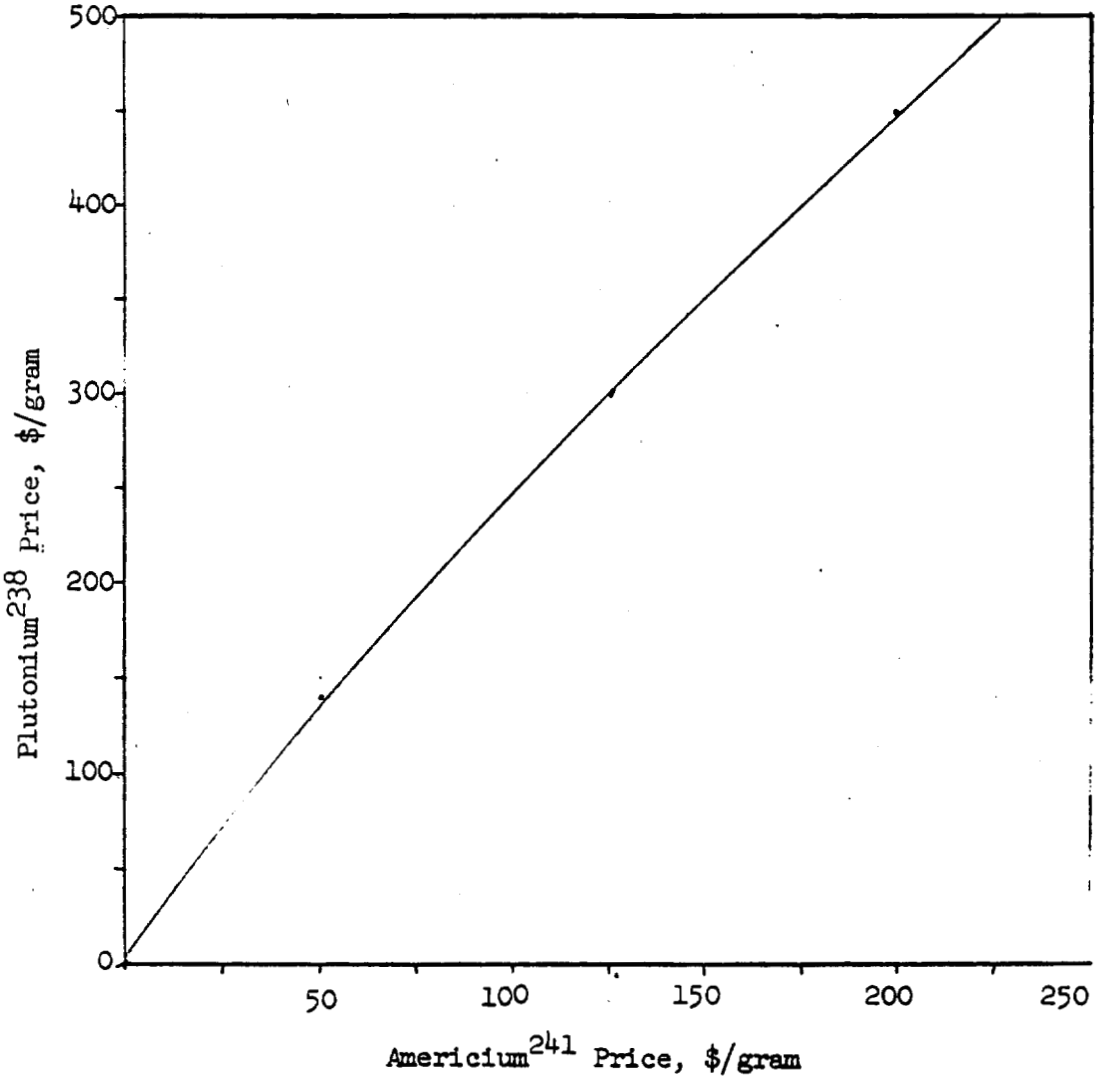

FIGURE 1.

Spatial Concentration of Plutonium in Fuel Elements

Preliminary investigation into the effect on α, (σ_c/σ_f) for Pu^{239} by spatial concentrations of plutonium in fuel elements was begun using the RBU and THERMOS codes. For the first experiment, a very simple system consisting of Pu^{239} uniformly distributed throughout an aluminum rod surrounded by water as a moderating medium was examined and a value of α was determined. Two other geometries where the plutonium is concentrated as a thin pencil in the center of the rod and as a thin annulus surrounding the rod were examined and the α for Pu^{239} was obtained for these systems.

Results for these experiments are incomplete due to the lack of convergence of the flux in the regions of interest as calculated by the RBU code. The values of α for Pu^{239} from the THERMOS code are being used to detect gross errors in the setup of the RBU model. Preliminary results from both RBU and THERMOS indicate a substantial reduction in alpha may be achieved by concentrating the plutonium (thin pencil) which promotes shielding of the resonances where alpha is high.

Code Development

1. Modification

Modifications have been made to the curve fitting and plotting code, CURVES, which will improve the operation of the code by allowing data to be entered on a single card rather than on two cards. Also, the code has been changed so that excess data occurring outside of the area of interest will be automatically eliminated from curve fitting.

The OPTIMIZER code, which determines an optimum minimum fuel cost as a function of selected reactor parameters, is being rewritten to accommodate changes in the output format of the MINIMIZER code, which generates minimum fuel costs as a function of exposure. Also, the number of reactor parameters that may be examined has been doubled.

2. Fuel Cycle Analysis Chain

The Fuel Cycle Analysis Chained Computer Programs Guide (HW-79951) was completed and is being cleared for offsite distribution. It will be made available to universities and interested laboratories, and it can be reproduced in printed card or tape form. Part I of the document contains instructions and data formats for using the twelve main computer codes in the Fuel Cycle Analysis Chain. Part II is a printout demonstrating six of the principal codes which includes burnup calculations for a PWR, and economic evaluations for a number of economic con-

ditions. Part II A, the magnetic tape, contains the programs produced from source tapes each containing one or more programs in FORTRAN form. These source tapes are assembled by the COPCAT program which prepares them for offsite use.

NEUTRON FLUX MONITORS

Information was received from GE-APED that the U-234 coating on the inside of one of two neutron flux detecting regenerating ion chambers being fabricated and flaked off. It was indicated the chamber would have to be disassembled, cleaned, and recoated. It could not be ascertained when either chamber would be completed and shipped.

One experimental B-11 beta current neutron flux monitoring chamber was fabricated with success in maintaining appropriate high resistance in the unit. The long mineral oxide cable and chamber assembly measured more than one teraohm resistance from the center wire to the sheath. Most of the required mechanical components have now been fabricated for assembly of the cable test. Laboratory experiments will be conducted prior to in-reactor testing.

Another microwave neutron flux monitor experiment was conducted at KW Reactor. This test used the cross-coupling attenuation technique. The probe assembly was inserted in-core on two different days to check reproducibility of obtained results. Measurements were made using the standing wave ratio meter and an interferometer. A change in attenuation was noted as the flux increased during gradual insertion of the assembly; however, instability developed and the readings became quite erratic. The cause for this is not known at this time; however, it is suspected that temperature-caused waveguide expansion or resistance changes may be the difficulty. Complete analysis of the obtained data was initiated in an attempt to ascertain the causes of the observed instability.

NONDESTRUCTIVE TESTING RESEARCH

Electromagnetic Testing

New oscillators and amplifiers are being built for the multiparameter tubing tester. The oscillator chassis, which consists of four oscillators and a bridge drive circuit, is completed. Modified Colpitts crystal oscillators are used to generate frequencies of 250 kc, 7 kc, 22 kc and 6 kc. First field tests of the multiparameter units are planned for in-place inspection of reactor process tubes.

Work on probe suspension design for the rotating air core transformer was continued. Improvements were made to assure more uniform pressure of test coils against the tube wall surface, and to eliminate "lift off" signal caused by eccentricity of the tubing internal diameter.

Fundamental Ultrasonic Studies

The measurement of shear wave attenuation coefficients continues to be difficult. The technique which has been used for generating shear waves requires bonding the transducers to the test specimens with phenyl salicylate. Although the sample preparation and bonding methods were carefully controlled, the reproducibility was found not to be sufficient for attenuation measurements at low frequencies. Individual measurements also required the use of excessive time which was another disadvantage.

Shear wave transducers are not available at frequencies above about 5 Mc and originally it was thought that higher frequency measurements could be obtained by driving the available transducers at odd harmonics. This also did not prove favorable as there were unusual and troublesome ultrasonic echo variations near the harmonic frequencies. In view of these difficulties, studies were undertaken to determine if shear wave attenuation could be measured by other methods. Shear waves can be generated by obliquely incident longitudinal waves, but in attenuating media these shear waves are inhomogenous waves. The lack of understanding of how inhomogenous waves propagate precluded the use of oblique angle methods previously. However, recent studies by Applied Mathematics Operation, HL, have shown that attenuating coefficients can be measured by this method. Since longitudinal waves are used, frequencies higher than the 5 Mc limit can also be readily obtained.

Further qualitative explanation of critical angle test effects became apparent this month. Previously it was reported that beams reflected near the critical angle had amplitude and phase changes across the beams. Experimentally it was found that there are essentially two amplitude peaks across the reflected beam; one which is usually substantially lower in amplitude. Between these peaks the amplitude drops to a minimum or null. These peaks also have 180° phase shift and therefore wave front overlap is responsible for the null signal. It is believed that one peak is from a portion of the beam which does not generate appreciable boundary waves because incident angles within this portion are below the critical angle. The other peak is that portion which results from boundary waves and therefore should be sensitive to the acoustic properties of the surface layer. A null signal change can then be interpreted as a shift in the relative balance of the interfering waves; the changes being due to differences in the acoustic properties of the surface.

It is hoped that eventually it will be possible to simultaneously measure four surface properties of a metal, the two velocities of propagation and the two attenuation coefficients.

Heat Transfer Testing

Initial experiments with thermal pulse transducers are promising, but indicate the need for greater sensitivity than has been obtained to date. Theoretical studies made to obtain useful sensitivities have shown that a rubber backed transducer using a .005 inch thick air coupling layer and 1 cal/cm^2 heat input would give a maximum thermal signal change of only .004°C for a 5% difference in thermal diffusivity of an aluminum sample. Helium or water coupling would result in thermal signal differences of .02 and .09°C per unit heat source intensity, respectively, under the same conditions. Heat inputs greater than 1 cal/cm^2 are possible, and the transducer sensitivity will increase almost in direct proportion to the source intensity.

The theoretical study has also shown the importance of selecting the proper backing material. A quartz backed transducer, using a .005 inch thick water coupling layer on an aluminum sample would give only 1/3 as much thermal signal change, for a 5% change in thermal diffusivity of an aluminum sample, as that obtained with rubber backing.

Fatigue Detection

Preliminary fatigue detection work using ultrasound and eddy currents continued. A Krouse fatigue specimen made from an aluminum alloy was examined ultrasonically. A pair of samples had previously undergone fatigue at a stress level of 20,000 psi for 13.2 x 10^6 cycles at which time one of the samples failed. The sample which had not failed was examined with ultrasonic critical angle techniques similar to those previously reported. Signal amplitude changes were observed which correlated well with the distribution of fatigue in the sample.

Initial eddy current tests on the Krouse fatigue samples also showed promise for detecting fatigue. However, in subsequent testing the initial results could not be reproduced. The eddy current equipment is therefore being modified to provide improved response.

The copper test sample surface preparation was improved by electropolishing. Machined surfaces had intolerable thickness variations which were reduced by lapping followed by the electropolish. Dye penetrant tests indicated all specimens except one were acceptable. Some of these samples were also given critical angle tests to assess their condition prior to

fatiguing. The aluminum and stainless steel samples are in various stages of preparation.

During the aforementioned critical angle tests it became apparent that accurate specimen alignment will be necessary. Accurate transducer and specimen holders and positioners have been designed and are being fabricated. The basic ultrasonic tank and fixture design is essentially a duplication of existing equipment used for fundamental ultrasonic studies. Modifications to this unit will permit its use for fatigue studies as well as for general future ultrasonic test problems.

Ultrasonic Imaging

Promising results are being obtained with optical methods of imaging ultrasonic fields. Results of an experiment in which an ultrasonic beam impinged on a water surface after having propagated through a wire mesh screen were particularly encouraging. In this experiment coherent light (generated by a He-Ne laser at 6358A°) reflected from the liquid surface projected an image of the wire screen in surprising detail.

In further tests thickness step wedges made up of several layers of aluminum foil were used as objects to demonstrate detection of thickness variation. The transmission of ultrasound through lucite and aluminum specimens up to 1/2 inch thick was demonstrated.

A holder was devised to stretch aluminized mylar film across the surface of the water in an effort to eliminate the detrimental effects of water surface movement and to increase the amount of light available in the image, but no image could be observed when the mylar film was used.

Continuing effort will be made to utilize a laser beam to obtain ultrasonic images with special wavefront reconstruction techniques. This work will employ optical principles being used by others in the development of lensless photography techniques.

Nondestructive Testing of Isotope Heat Sources

An infrared method for determining the power output of isotope heat sources is being developed, and a sinusoidal steady state thermal method for detecting residual stress in containment vessels is being investigated.

Equilibrium outer surface temperatures on vertical cylinders cooled by free convection are a function of power density and surface emissivity. Experiments with an electrically heated stainless steel dummy isotope heat source have been performed to study the influence of normal variations in

ambient conditions on the surface temperature. With longitudinal free convection cooling in air, the surface temperature of a 2.5 inch long by 2.5 inch diameter cylindrical source was approximately 470°C after several days at a power of 146 watts. The surface emissivity of the stainless steel increased due to oxidation during the first day of operation, and this resulted in a decrease in temperature during that time. The sensitivity of surface temperature to changes in power was approximately 1.5°C/watt after the surface had become oxidized. Although no attempts were made to protect the heat source from changes in ambient conditions, the surface temperature change was a maximum of only 8°C for a constant power output of 146 watts. Thus, the maximum error in power measurement would have been about 5 watts. The measurements were made during a ten-day period after an initial few days operation to reach an equilibrium surface emissivity. Improvements in accuracy should be possible by control of ambient conditions. Methods for minimizing the influence of emissivity on surface temperature of the heat sources are being investigated. These methods involve the use of external infrared source to balance radiation losses.

Both ultrasonic and radiographic tests were performed on spherical shaped isotope containment cells. Wall thickness profiles were then plotted along two planes. The design criteria were outlined for a mechanical system to perform this inspection. Some components have been placed on order while the remaining parts will be fabricated as the detail drawings are completed.

Samples of the several candidate metals which may be used in the containment cells have been received. The ultrasonic properties of these samples will be investigated and recorded so that they may be compared to the metal when it is used. Several transducers have been fabricated for this purpose. Methods of obtaining low frequency, highly damped transducers for inspecting the large grain size inconel metal are being developed.

Ultrasonic Transducer Development

Methods of fabricating uniform piezoelectric transducers are being developed. The basic transducer housings and holder arrangement capable of being used on a variety of transducer sizes was designed. The piezoelectric transducers themselves are mounted on precisely machined surfaces so that the mechanical and ultrasonic axis of these units should coincide. Techniques for fabricating the transducer backing members are being improved. Several units with damping factors of three have been constructed and are being used. Their performance compares very favorably to commercially available units, yet they are more economical and durable.

A method of generating ultrasonic waves by using the forces associated with the electric field present when a voltage is applied across a capacitor was also investigated. The wave is generated within a 3-inch rod which also serves as one plate of the capacitor. Although this system is not very sensitive, very broad band ultrasonic signals are generated and detected without the use of a coupling medium. By measuring the velocity of longitudinal and shear wave propagation the tensile properties of the metal rod are determined. The broad band nature of the pulse shows that some wave shape changes also occur. These wave shape changes may be related to additional metal properties. Since the capacitor transducers are not limited by temperature this system is also potentially capable of performing measurements at elevated temperatures so that the metal properties could be determined up to the melting point of the metal.

BIOLOGY AND MEDICINE - 06 PROGRAM

Atmospheric Physics

Fabrication, check-out, and installation of meteorological and auxiliary equipment in the L-19 aircraft have proceeded satisfactorily. Special containers for sensing equipment were received for attachment to the bomb hangers. The meteorological instrument panel and recording camera were installed and found to be stable in flight. Additional vacuum systems were installed for use with the air samplers. The meteorologist-pilot has flown the aircraft when possible and has achieved the proficiency needed for the experimental work planned in diffusion, transport, and scavenging studies.

Three additional field experiments using elevated sources during nighttime atmospheric stabilities were made during August. Two of these were at the previous release level of 185 feet, while the third was made from 365 feet. These tests will assist in studies of the effect of source height on ground-level dosage patterns. Analysis of the twelve tests conducted last year using a 23-foot release height has shown that:

1) The travel time from source to maximum exposure at the ground was proportional to the Richardson number. (This number is a conventional index of atmospheric stability.)

2) Beyond the point of maximum, the normalized exposure curve asymptotically approached the average curve for ground-level releases.

3) The value of the peak exposure was inversely related to the variability of the wind.

The last two results are consistent with those being obtained with elevated releases in unstable atmospheres, in which it is found that the cross-wind variance of the exposure is linearly related to the variance of the wind speed. Predictions made from the theoretical equation

$$\overline{v'^2}\, T^2 = \sigma_y^2$$

where $\overline{v'^2}$ is proportional to the average cross-wind turbulent energy and T is the travel time, were generally correct to within 20% of observed exposure variances when the averaged wind record was long compared with the travel time.

Radiological Physics

The whole body counting program in Alaska was completed for the summer. The average adult body burdens of Cs^{137} are: Anaktuvuk Pass, 1280 nCi; Arctic Village, 614 nCi; Kotzebue, 321 nCi and Point Hope, 64 nCi. The average body burden at Anaktuvuk Pass was 100% higher than that obtained during the summer of 1963 and 200% higher than during the summer of 1962.

Additional correlations were made at Arctic Village between the shadow shield and the unshielded 3 inch NaI crystal technique. It was possible to make a quick side trip to measure the body burdens of 14 Eskimos at Point Hope with this technique. The necessary equipment included the 3-inch crystal, analyzer, and motor generator.

The highest Cs^{137} body burden was measured in a Caucasian from Ambler, Alaska. This individual's body burden of 3.0 μCi equals the maximum body burden recommended by the ICRP for individuals in a population at large.

The Hanford mobile whole body counter was taken to Lafayette, Oregon, to measure the Cs^{137} body burdens in monks at a monastery. Because these people have a completely meat-free diet, it was thought that their body burdens would be lower than average. Preliminary results give an average body burden of 35 nCi which is above average for this area and above the 29 nCi average of another group of men located at the Jesuit Novitiate about 15 miles from the monastery. The novices eat a normal diet. Although the data analysis is not complete, it appears that the monk's above-average body burdens are due to large quantities of whole wheat bread in their diet. The whole wheat flour contains 2 to 3 times as much Cs^{137} as normal white flour.

Two significant observations have been made thus far in an experiment being done in conjunction with Radiation Chemistry on Sr^{85} body burdens. The

Sr^{85} does not appear in the hair for approximately 10 to 15 days after ingestion into the blood stream. There is an apparent decrease in whole body counting efficiency which coincides with the appearance of the isotope in the bone. This decrease in counter efficiency is apparently due to an increase in shielding provided by the bone.

The electronic circuits necessary for the modification of the Nuclear Data analyzer to allow determination of local energy deposition via the Rossi technique have been designed, built and debugged.

The helium ion separator being developed for use with the 2 MV Van de Graaff has been successfully tested for short time intervals. A doubly charged helium beam of up to 0.5 μamps and 2.6 MeV has been obtained. Minor modifications are now being incorporated in the system to improve operating characteristics.

Minor problems have slowed the calibration work on the Linfield pulsed X-ray machine. Excessive noise in the pulse was traced to loose connections on the capacitors and pulser cabling. A liquid nitrogen trap was installed to remove water vapor in the spark gap column of the pulser. Calibration work is now proceeding.

Instrumentation and System Studies

Extensive testing at the Biology Inhalation Laboratory of the smoke inhalation control system for canine experiments indicated a need for a new design of the employed masks. Three masks are being fabricated. These will cause the dog to breathe through the mouth at all times, thereby improving control and permitting easier maintenance. General system operation has continued to be satisfactory.

Mechanical tests of the modified scanner-drive system for the Biology dog counter indicated that correct operation was achieved at all desired scanning speeds up to 10 in/min. The detected in-vivo radioactivity is indicated on a chart recorder. Several minor difficulties involving electronic noise are to be resolved before the modifications are completed.

Gamma spectra measurements were continued at the Biology fish trough installation located in the KE Reactor area. It is tentatively planned to employ one scintillation detector with a logarithmic response area radiation monitor, as previously developed, to provide measurement of approximate gamma dose rates to the fish.

Three regulated power supplies for use with thermal precipitators at the Biology Inhalation Laboratory were designed and are being fabricated. The

precipitator units incorporate heater and air supplies along with timing and monitoring circuits.

Laboratory experiments were conducted on a developmental small wound probe for detecting minute amounts of plutonium within human wounds. The experimental scintillation detector included a selected low noise phototube, 5/16 inch diameter quartz light pipes of 1/2, 1, and 1-1/4 inch lengths, and a tiny NaI(Tl) crystal to measure the 17 keV X-rays from Pu-239. Sensitivity measurements were not completed.

Laboratory investigations were continued on detection methods for differentiating between filter collected airborne uranium and plutonium isotopes. Alpha energy analysis techniques appear to be inadequate; therefore, gamma and X-ray detection methods are being investigated.

Experimental fabrication was accelerated on another prototype, pocket size, signaling dosemeter, which incorporates a new design "pencil" automatic-recharge ion chamber and solid state circuitry. The plastic-shell ion chamber was completed and it is being incorporated in the dosemeter for which the printed circuit is completed. The unit will provide an audible signal following dose accumulation of about 50 mR.

Laboratory measurements were conducted regarding the use of lithium-foil covered surface barrier diodes and various sized spherical polyethylene moderators as neutron dose-rate detectors. Measurements, using Pu-Be fast neutron sources, indicated that a directional dependence of about 10% is being encountered. With proper biasing of the diodes, no gamma interference problems were noted in fields of about 5 R/hr.

Progress was achieved on the development of circuits for the experimental animal physiological function and dose telemetry system, slated for use in Biology Laboratory experiments. Tests were conducted on the thyroid uptake channel where a miniature GM tube is used to measure I-131 uptake. Using the radiotelemetry link, measurement accuracies to 1% were achieved at rates to 7 x 103 counts/min; the sub-carrier oscillator frequency was increased from 3 kc/sec to 15 kc/sec to permit measurement to 3.5×10^4 counts/min. Operation of the complete thyroid uptake channel appears to be fully satisfactory and development work is being accelerated on the blood pressure and respiration rate channels now that suitable transducers have been received.

Circuit development was accelerated on the amplifiers and integrators for use with the peak pulse reader instrument to be employed in dosimetry studies. Pulse heights from 10 mV to 10 V were measured with an accuracy of 1% of full scale for artificial pulses using the developed solid state

circuits and a digital voltmeter. However, tests with readout pulses were not satisfactory due to excessive electronic noise coincident with the pulses. Considerable circuit modifications appear to be necessary to circumvent the chronic noise problem.

In conjunction with the development of a multiplier phototube single electron counter for use in dosimetry studies, development was conducted on avalanche transistor circuits to provide a fast rise time pulse generator for simulation work. Pulses of 4.5 V magnitude into 50 ohms with less than 1 nsec risetime and 2 nsec width were achieved. Such pulses are quite similar to noise pulses from the Amperex 56 AVP multiplier phototubes. Two of the generators can be connected to provide a means of measuring pulse-pair resolution of fast amplifier and discriminator circuits. In addition, two single stage feedback transistor amplifiers were developed with risetimes of about 2 nsec, and a single stage amplifier with emitter degeneration provided a current gain of 1.5 with a 0.5 nsec risetime.

Acceleration was continued on the field testing of five remote data stations for use in the Atmospheric Physics radiotelemetering system. All five units were completed and are now in operating condition with extensive field testing under way. Results achieved appear to be satisfactory with correct meteorological and radiation measurement data being obtained in the field. In addition, a power supply was designed, fabricated, and installed to replace batteries in the central station. The regulated solid state supply provides 2A at 2Vdc. A monitor was designed to provide data useful in testing the central station.

Solid state circuit improvements were incorporated in bread-board form on the pulse shape discriminator instrument being developed for use in dosimetry studies by Radiological Physics. The development circuitry is operating successfully with Fe-55 being measured using the circuit and selected low-noise multiplier phototubes.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis Program

Isotopic analyses were provided on program samples during the month in accordance with current schedules.

A program for the new PDP-5 computer was written and is being debugged. The program will process digital data in the form currently generated by the mass spectrometer for this program.

Acceptable alumina parts for a vacuum-lock sample changer for the I. A. Program mass spectrometer were finally received. Delivery of the parts was 9-1/2 months behind the date originally scheduled by the vendor. The vacuum-lock is being assembled on the ion-optical test bench for testing prior to installation on the mass spectrometer.

EXPERIMENTAL REACTOR PHYSICS FACILITIES

PCTR Operation

The PCTR was operated routinely during the month. There was one unscheduled shutdown due to an electronic failure. The experiment to measure the uniformity of boron content and the total effective boron cross section of boron impregnated polyethylene disks was completed. Three sets of mica detectors were irradiated to detect uranium inclusions in zirconium welds. A reactivity comparison of VSTR fuel disks was completed to select disks of uniform reactivity worth for an experiment with polythylene moderated U-235-Al fuel. The closing times for the control rods and safety disks were measured as routine operating tests. The average closing time for the control rods is 0.20 seconds with the maximum time 0.25 seconds, and the minimum time 0.16 seconds. The drop time for "B" disk was 0.60 seconds and for "C" disk 0.56 seconds. The drop time for the disks includes the delay in the photocell circuit.

TTR Operation

The TTR was operated intermittently with no unscheduled shutdown. An experiment to measure the behavior of neutron dosimeters was completed during the month. A set of Au and Pd foils was irradiated for normalization.

PRCF Operation

EBWR experiments continued. Worth measurements in the center of the core were completed for three, one-half inch diameter Pu-Al fuel pieces (44" long at 1.8 w/o Pu, 6" long at 1.8 w/o Pu, and 4" long at 2.7 w/o Pu). Worth measurements for the smallest fuel piece were taken as a function of its elevation in the central lattice position. Similarly, vertical traverse data were taken for a 1/2" dia. x 2" long Cu rod. Au, Pd, Cu, and Lu irradiations were completed with and without Cd covers for cell flux measurements and for measurement of radial flux distributions across the core. Moderator level sensitivity measurements were extended down to 85 inches, which is approximately 15 inches below top of the fuel. (Earlier measurements had provided data down to 90 inches.)

Temperature coefficient data were taken over the range of 28.3°C to 72.3°C. This was the first PRCF experience at temperatures above 42°C. One of the objectives of this experiment was to determine a maximum temperature capability for the PRCF system. Performance of the shutdown mechanisms was watched carefully at each increment of temperature increase, and the experiment was terminated when an interference was detected on a test insertion of one of the sheets. This occurred at a moderator temperature of 79°C. At this time, with the reactor cell ventilation turned off, cell temperature was 106°F and relative humidity was approaching 85%. Other problems caused by the high temperature and high humidity did not appear to be limiting. To evaluate the expansion of the "Lexan" lattice plates, the linear expansion coefficient for "Lexan" was measured with strain gauges over a range of 32°C to 91°C. A coefficient of 6.63×10^{-5} in/in/°C was measured compared to a value of 7×10^{-5} in/in/°C as reported by the manufacturer of this material.

Construction work began under Project CAH-119. This project combines an assembly area and office space for PRCF with miscellaneous improvements for PRTR. Construction work interrupted PRCF operation once during the month for a duration of 70 minutes.

Assembly of components and mockup of the second H_2O moderated core structure was completed preparatory to installation next month. This provides "Lucite" lattice plates for experiments with 1/2" diameter fuel rods on a lattice spacing of 0.80". It is set up for a fuel length of 44", using the existing control and shutdown mechanisms.

CUSTOMER WORK

Weather Forecasting and Meteorological Services

Meteorological and climatological services included 1) summarization of pertinent weather and river records for AEC, 2) weather watch for electrical tie-in at N-reactor, and 3) assembly of meteorological data pertinent to a legal case.

Weather Summary

Type of Forecast	Number Made	% Reliability
8-Hour Production	93	88.2
General	62	87.9
Special	167	89.0

The past month was the coolest August in 53 years of record for the Hanford

area. In August 1912 (previously the coldest) temperatures averaged 70.5. The August average this year was 69.8.

Although August precipitation slightly exceeded normal, the totals for the first 8 months of the year stood at an all-time record low of 1.74 inches.

Instrumentation and System Studies

Engineering assistance was rendered to Plutonium Metallurgy, HL, in witnessing acceptance tests on an electron microprobe X-ray instrument being fabricated offsite for use at Hanford.

Fabrication completion was achieved on the scintillation detection and solid state circuitry aerial gamma monitor for Environmental Monitoring, HL. Laboratory testing and calibration were initiated.

The assault mask outer surface beta-gamma detector for the Laundry Facility mask monitor was completed and tests appeared promising. In addition, all necessary solid state printed circuits were completed. Final system assembly was initiated.

An instrument to check the detection response of various HAPO portable and line-operated alpha monitors was designed and fabricated for use by Calibrations, HL. The instrument provides a total count readout for the various instruments over pre-selected counting time periods.

Field testing was completed on the U-235 fuel enrichment monitor developed for Metal Fabrication Development, HL. General operation appears to be as satisfactory as can be achieved with the present design, although consideration is being given to incorporation of shielding to reduce background effects. The monitor is now in routine use by the customer.

The simulation of the high temperature gas loop for Reactor Fuels Research and Development Operation continued. Four Bailey, two-mode controllers were coupled to the simulation. The simulation was used to determine procedures for finding the control range for the loop. To date, this study has raised questions regarding the adequacy of the control system in that (a) a power failure to the heater may cause rapid cooling transients in the system, and (b) a failure of loop gas flow might cause melting of the heating element if control settings are not properly chosen.

A rough draft report on the creep data logger was completed. The report was written in two parts, the first an introduction to the data logger presenting over-all design philosophy and theory of operation, and the second part an operation and maintenance manual. The data logger has been operating with no apparent radio frequency interference since it was

enclosed in a steel bay with filter capacitors on all incoming loads.

A study designed to determine the constants for mathematical model of Columbia River flow from Priest Rapids Dam through the Hanford reservation was started. Flow rates at Priest Rapids Dam and at various points along the river are supplied as functions of time. The problem involves fitting constants from a standard mathematical model to the data given. After this has been done for several river reaches, the dynamic flow characteristics of the Columbia River between the dam and Hanford site will be simulated on the analog computer.

Optics

Modifications were designed which permit the use of 5-1/2 inch wide roll film on metallographs at the Radiometallurgy Lab. A similar camera, designed and built in the Optical Shop, has been in use at the Radiometallurgy Lab for more than a year recording thousands of pictures required for the large mosaics which are made of fuel element cross sections. The modifications designed this month will be applied to two new cameras and will permit the use of polaroid and roll film.

During the period covered by this report, the following shop work was performed:

1. One Redox three power crane periscope head was repaired.
2. A pyrex chemical process tube was reamed out to accept pulse column discs.
3. Ultrasonic fixtures were fabricated for Physical Measurements.
4. One pair of binoculars was collimated.
5. Twenty copper fatigue test specimens were lapped for Physical Measurements.
6. Two crystal manipulators were fabricated for Physical Testing.
7. A high pressure mercury arc lamp housing and condenser lens was fabricated and assembled.
8. Two laser rods were silvered.
9. Fifty bell jar windows were gauged for flatness.
10. A shutter was repaired for Radiometallurgy Lab.

Physical Testing

An all-out, coordinated effort was made to assess the condition and cause of damage on sixteen dump condensers at N Reactor. Analysis of three condensers by eddy current methods showed the tubes were worn by fretting action of "band-it" straps holding the tubing in the heat exchangers.

Only the tubes on the outside of the bundle were seriously affected, and could be visually inspected from access to the shell side of the exchanger. All units were opened, visually inspected, repaired, and the closure welds radiographed.

An accurate and detailed map of the export water lines and its auxiliary systems resulted from the leak survey of the system between 100-D and 100-F areas. Eighteen leaks were found and identified in the auxiliary systems, no leaks in the export line itself. The map is issued as Plot Plan H-1-70530.

The development program for gamma ray image intensification is progressing well, a 2-4T level of sensitivity was achieved in both steel and uranium, which approaches the sensitivity of conventional film radiography. Iridium-192 was used as the source.

Notch standards of 1.8 and 2.9 mils deep were punched on the inner surface of sheath tubing prior to manufacturing a ceramic fuel element. After swaging the element to final size the defects were readily resolved with ultrasonics. This demonstrates the feasibility of production testing both vibratory compacted and swaged fuel elements after final assembly.

Engineering assistance was given during the investigation of an induction furnace in the 234-5 Building. It was found the generator delivered only thirty percent of the power indicated by the field current tester. The meter was rewired to indicate the true power. Additional output was achieved by designing a work coil to improve the coupling between the coil and the furnace and to match the impedance to the generator.

A rotating transformer and eddy current coil assembly has been successfully completed for helically scanning the inner bore of process tubes. Two point coils are utilized, connected to an electric drive motor. This method improves the sensitivity over circumferentially scanning as well as locates the position and orientation of a defect.

Samples from the supplier and off-site inspection laboratory of stainless tubing for Purex concentrators showed a grain size so large that the intended five percent ultrasonic test was impractical. The arbitrated solution to the problem was to lower the inspection level to ten percent sensitivity and to sort the tubing into fine grain and coarse grain categories. The coarse grain structure does not affect the corrosion resistance, but does decrease the sensitivity of inspection levels.

INSTRUMENT EVALUATION

Final calibration tests were completed on the last three scintillation and solid state circuitry combined alpha-beta-gamma hand and shoe counters. Ten instruments have now completed testing and four are in service. Calibration tests showed the following detection efficiencies: alpha hand probes, 8% to 12%; beta-gamma hand probes, 5% to 7%; and beta-gamma shoe probes, 2.5% to 4%. Such efficiencies are satisfactory for plant use.

Bids were received regarding offsite fabrication of eight alpha-beta-gamma hand and shoe counters which incorporate new circuits and detection probes. The new design achieves an apparent 20% cost reduction over the original ten counters described in the foregoing paragraph.

Acceptance tests were completed on 70 of 100 new CP-type portable exposure rate measuring instruments.

Investigation into leakage and consequent corrosion problems with mercury batteries in certain HAPO portable GM instruments indicated that zinc-alkaline batteries should be substituted. This is being done.

One of a number of HAPO single-range scintillation area radiation monitors was converted from the usual 0-200 mR/hr range to 0-4000 R/hr for a special application.

R S Paul

Manager
PHYSICS AND INSTRUMENTS LABORATORY

RS Paul:mcs

CHEMICAL LABORATORY

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 02 PROGRAM

IRRADIATION PROCESSES

Reactor Coolant Water Studies

Process water measurements were made and calculations completed on laboratory data needed to guide a proposed half reactor test of the reduction in reactor effluent radionuclides through the use of sodium silicate addition to the process water. This represents a field test of promising treatment found in our laboratory studies.

Columbia River Studies

A Columbia River travel time study was made at a flow rate of 1.7×10^5 cfs using a "pulse" of I-131 tracer which was introduced by reactor operations. The values obtained are given in the table. The flow rates at Umatilla and The Dalles reflect the addition of the Snake River.

Location	River Flow Rate (cfs)	Time (hours)
100-B Area - Pasco	1.7×10^5	16
100-B Area - Umatilla	2.22×10^5	64
100-B Area - The Dalles	2.03×10^5	112

Measurements were also made of the Na-24 concentrations. Na-24 is produced at a nearly constant rate, so that travel times can be estimated by use of its decay rate. Comparisons with the rates obtained from the I-131 measurements will calibrate this technique so that measurements of travel time can be made without waiting for an unusual operation which introduces a tracer in a short burst.

Overheated N-Reactor Fuel Study

Special fuel pieces were fabricated and charged into N-Reactor by NRD. These 8.33-inch long elements are scheduled for discharge late in December or early in January, 1965, and will be used in the thermal stressing and fission product release studies of N-Reactor fully-irradiated fuels. Installation of the 50 KW induction heater was expedited and detailed planning for these tests initiated.

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Final analyses of photomicrographs of sectioned thermally stressed [redacted] elements were completed. These irradiated elements were those heated and quenched earlier this year. The report of this work now in draft is being revised to include the significant metallographic data.

Instrumentation needed for the overall study arrived and was tested.

SEPARATIONS PROCESSES

Dissolution of Thoria

Dissolution rates for Mallinckrodt sol gel thoria in a solvent initially 12.3 M HNO_3-0.025 M HF-$Al(NO_3)_3$ were nearly the same at 0.1 and 0.2 M aluminum and not greatly reduced at 0.5 M aluminum. At 0.2 M aluminum, dissolution rates at 0.1 and 0.025 M HF were the same. There appears no advantage from a dissolution standpoint to the use of greater than 0.01 M HF. Pretreatment of the thoria with sodium citrate-sodium hydroxide solution did not improve the dissolution rate in HNO_3-HF-$Al(NO_3)_3$ solutions. During the course of one dissolution experiment, a thick layer of thoria in the bottom of the dissolver was inadvertently heated to some unknown temperature well above the boiling point of the solution. The thoria, initially granular, was converted to a massive chunk difficult to break up. Subsequent experiments have attempted to define the temperature range in which the thoria becomes cemented when in contact with dissolvent. Formation of the cemented thoria has not been observed at temperatures in the settled sludge up to 150 C.

U-233 Support Studies

Work was concentrated during the month on the development of a protactinium scavenging process for use by the Purex plant during the forthcoming six-ton thorium test. Since feed to the solvent extraction battery will be acid deficient, protactinium scavenging with MnO_2 and PbO_2 under acid deficient conditions was first investigated. Results were not promising, typical decontamination factors of only 2 being obtained, with either preformed or coformed MnO_2 or PbO_2. In addition, the MnO_2 precipitates which were formed in acid-deficient solutions were prohibitively bulky and often colloidal. Decision was accordingly made (for the six-ton test) to acidify the feed solution, scavenge under mildly acidic conditions, and then re-adjust the pH prior to solvent extraction. Manganese dioxide scavenging of protactinium under acid conditions was rather thoroughly studied in the laboratory to define the effect of pertinent variables, after which hot cell tests were initiated. It appears that 98-99 percent Pa-233 removal can be achieved and that radiation decomposition will not be a serious problem. The latter conclusion is subject to confirmation with feed soon to be produced by dissolution, under flowsheet conditions, of a short-cooled thorium target element.

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Purex 1BX Column Development

Additional pilot plant pulse column runs using SFS (sodium formaldehyde sulfoxalate) as the 1BX reductant confirmed that the optimum introduction point was about six feet from the bottom of the plate cartridge. Only 16 to 29 percent of the theoretical amount of U(IV) was found in the 1BU stream. The relatively poor conversion ratio of the SFS to give U(IV) may have been due to poor solvent quality. Thirty-minute batch contacts of the 1BXF used in these studies with 2 M HNO_3-0.1 M sulfamic acid at 50 C gave conversion ratios of only 32 to 57 percent.

An unexpected corrosion reaction was discovered near the end of one of the pilot plant runs using a bottom interface for the first time. The green U(IV) color became greatly intensified, and a vigorous gassing (colorless) was observed above the SFS introduction point. Investigation of the column after the run showed that the stainless steel plates and spacers were severely pitted and that the highly colored 1BXP, collected at the peak of the reaction, contained dissolved stainless steel. The run was uneventfully repeated several days later. Laboratory studies have pin-pointed the SFS as the cause of the corrosion, but the reason for the sudden attack in the above run is not yet known.

Use of Sodium Formaldehyde Sulfoxalate as Plutonium Reductant

A Purex plant test of sodium formaldehyde sulfoxalate (SFS) as plutonium reductant was terminated when it was observed that SFS solutions are significantly corrosive to 304-L stainless steel. In subsequent laboratory tests, significant to severe corrosion has occurred in solutions containing from 0.1 to 4 M HNO_3 and as low as 0.005 M SFS while maintained at temperatures as low as 25 C. Induction periods preceding inception of corrosion have been observed in some cases. Plant tests will not be resumed unless operating conditions can be found in which corrosion is not a problem.

Trilauryl Amine Extraction of Np and Pu from Purex 1WW

Further studies were made toward defining the radiation and chemical stability of trilauryl amine (TLA)-diluent solvent during extraction of neptunium and plutonium from Purex 1WW. Portions of 0.3 M TLA-Soltrol 170 or dodecane solvents were contacted with equal volumes of 4 M HNO_3 or simulated 1WW for 48-64 hours at 40-50 C. Each organic was stripped with 0.05 M hydroxylamine sulfate and allowed to stand at room temperature. In all cases a white solid, as yet unidentified, precipitated from the solvents. Neptunium extraction capacity and amine titer of the supernatant solvent was reduced from that of the virgin solvent in all cases (to zero in some). A sample of 0.3 M TLA-Soltrol 170 was alternately contacted at 40-50 C with simulated 1WW while receiving Co-60

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radiation at 6 x 10^5 r/hr and stripped with hydroxylamine sulfate at 50 C. After 60 cycles, amine titer and neptunium extraction capacity were essentially the same as for the virgin solvent. Radiation exposure to the solvent was about 3.6 x 10^7 r during the 60 cycles.

Recovery and Purification of Americium by Chromatographic Ion Exchange

Promising tracer-level studies of the application of compact-band chromatographic ion exchange to the recovery and purification of americium-241 were described last month. Laboratory work has not been completed with a fully successful macro-level run. The feed contained all of the ingredients expected in plutonium reclamation waste (including saturation with DBBP) plus 65 mg/l Am-241. The feed was loaded onto a Dowex-50 column (hydrogen cycle) and then eluted sequentially through two successive columns (also in the hydrogen cycle) with 0.03 M DPTA at a pH of 4.5. Columns were operated at 60 C to improve kinetics. Americium recovery was greater than 96 percent, and only aluminum (equivalent to about 3 percent) was present as an impurity. Subsequent oxalate precipitation of the americium would be expected to remove this small quantity of aluminum. All other potential impurities were below spectrographic detection limits (generally < 1 ppm).

The process is similar to that for promethium purification and can be operated in the same equipment. Although developed for 234-5 Building application, it could be utilized by a power reactor fuel processor for simultaneous recovery of purified promethium and purified americium. A formal report is being prepared.

Thermobalance Studies of Plutonium Oxalate Calcination

The Cahn Electrobalance installation has been completed, and the balance was used in preliminary studies of the thermal decomposition of plutonium(III) and (IV) oxalates. Further evidence was obtained for the formation of $Pu_2(C_2O_4)_3$ as an intermediate in the thermal decomposition of $Pu(C_2O_4)_2 \cdot 6H_2O$ in an argon blanket. Analysis of the PuO_2 produced by heating $Pu(C_2O_4)_2 \cdot 6H_2O$ in argon to a maximum temperature of 600 C showed the carbon content as 3000 ppm. Calcination conditions will be varied in future experiments in an effort to reduce this value.

Electrochemistry of Plutonium in Molten Chloride Solutions

Previous monthly reports (e.g., April 1964) have presented evidence for the formation of plutonium(II) as an intermediate in the reduction of plutonium(III) to metal. Recent, more refined studies have now shown that the polarographic wave which was originally ascribed to a subvalent plutonium species was in fact caused by the presence of oxygen, in some form, in the melt. This source of interference was removed by using a

zirconium getter (rather than copper) to remove oxygen from the argon blanket, and the data now indicate the plutonium(III) reduction to metal to occur in a single step.

Chronopotentiometric data indicate a diffusion coefficient of 0.67×10^{-5} cm^2/sec for plutonium(III) in eutectic LiCl-KCl, which compares favorably with that for bismuth(III) under the same conditions.

Disposal to Ground

Samples from a series of wells near the northwest end of the Gable Mountain swamp are reflecting the discharge of contaminated cooling water to the swamp from Purex plant in early June. Normally these wells contain $< 8 \times 10^{-2}$ pc β/cc. Samples taken in late July and early August showed concentrations of beta emitters up to 50 pc/cc. A gamma scan revealed, as expected, that about 95 percent of the activity was Ru-103 and Ru-106 with the remaining few percent being Zr-Nb-95. Additional samples are being taken on a routine basis to determine the peak concentrations. No untenable groundwater contamination situation is expected to result from this incident.

Strontium-90 was detected in ground water samples from two wells drilled through the gravel fill of the Redox 216-S-1 and 2 cribs (process condensate and cell drainage) soon after the facility was abandoned in 1956. For several years the concentration remained at about the same level, 1-2 pc/cc, and appeared only in these two wells. By the end of 1963, the concentration in the ground water had increased to 10 pc/cc, and during the past six months it has increased to 50 pc Sr-90/cc. These increases correlate well with fluctuations in the ground water table. Little variation was noted prior to 1961, but between 1961 and 1963 the water table elevation increased 2.5 feet. During the past six months a further increase of about 1 foot was noted. It appears from these data that as more of the contaminated soil column beneath the disposal site becomes inundated, the concentration of Sr-90 in the ground water increases. Migration of the radionuclide appears to be quite slow as none has been detected in nearby wells monitoring the crib. This information supports the need for investigating the effects of a Mile 348 Dam (rising water table and changing flow patterns) on 200 Area waste disposal.

Plutonium Aerosol Studies

A draft was completed of a literature search and commentary, "A Review of Research on Plutonium Releases During Overheating and Fires." This review with the bibliography should prove of material worth as a summary of current knowledge relating to plutonium aerosols.

The facility to accommodate the planned plutonium aerosol studies neared completion with the installation and testing of the 15 KW induction heater and the air dryer for the hood atmosphere.

WASTE MANAGEMENT AND FISSION PRODUCT RECOVERY

Full-Level Zeolite Storage Studies

Observation for pressure build-up of the strontium-loaded zeolite container continued through the month in B-Cell of the High Level Radiochemistry Facility. Pressure remained approximately constant at 12 to 13 psig for three weeks at 470 C, thus demonstrating that pressurization is neither rapid nor severe. Since about 8 psig of this pressure is due to hot air, only about 4 psig total can be due to water vapor, oxygen and hydrogen. In conjunction with the ex-cell cobalt-60 irradiation observations of rather rapid recombination of hydrogen and oxygen on dry zeolites, it would appear that the equilibrium pressure due to radiolysis products is probably quite low. Observations are continuing. When pressure studies are completed, an attempt will be made to elute the sorbed strontium, to determine to what degree it may have become irreversibly fixed on the zeolite.

Purification of Recovered Cesium

Preliminary results with simulated process solutions show that cesium, recovered by ion exchange with zeolites from Purex alkaline supernatant waste, can be readily purified by alum crystallization. A 100 percent excess of ammonium alum was added to a simulated cesium product solution (0.64 M Na^+, 0.08 M Cs^+) and the cesium alum crystallized at 5 C. The supernatant liquid was decanted and the cesium alum dissolved in hot water and twice recrystallized at 5 C. About 99.8 percent of the sodium was separated from the cesium by the three crystallizations. Cesium recovery was 90 percent. The cesium in the waste fraction can be recovered by alum scavenging for recycle if desired.

Cesium Removal from Redox Alkaline Waste

Methods for regenerating Duolite C-3 resin used in cesium extraction from Redox SX wastes were studied. Best results were obtained when the column resin bed was treated with 3 column volumes (cv) of 2 N NaOH at 2 cv/hr and then recycling with 4 cv of 8 N NaOH at 2 cv/hr for four hours. Fluidization of the bed was not necessary. Three load, elution, regeneration cycles were run with this regeneration scheme, and 1 percent breakthrough points were 12, 9 and 11 column volumes of actual waste.

Strontium Semiworks Ce-Pm Separation

Tests are in progress to compare the radiation and chemical stability of a new hydrocarbon diluent (NPH) with that of Soltrol 170 when used in the Strontium Semiworks process for separating cerium from other rare earth elements. The D2EHPA-diluent solvent is contacted with simulated rare earth-containing feed and then stripped with 2 M HNO_3 while being irradiated in a Co-60 source. Radiation exposure to the solvent is about 27 watt hours per liter per cycle. A Ce(IV) distribution ratio is determined for the solvent after each cycle by a standardized procedure. During five cycles completed to date, Ce(IV) distribution decreased for solvents prepared with either NPH or Soltrol 170 as diluent. However, the Ce(IV) E_a^o is still relatively high for both solvents, greater than 300 for D2EHPA-NPH and 150 for D2EHPA-Soltrol 170.

Technetium Studies

The technetium metal powder, whose preparation was described last month, has been vacuum arc melted to a massive ingot (by Metallurgy Development Operation) and the latter analyzed. Oxygen content was < 2 ppm, hydrogen < 0.006 ppm, and nitrogen < 3 ppm.

In other work, analysis of data obtained during the hydrogen reduction of NH_4TcO_4 has been completed. Two sequential reactions were observed. First was the formation of TcO_2 at about 210 C. This reaction was strongly exothermic and caused a rapid increase in furnace temperature to about 100 C above the operating level. The second reaction, reduction of TcO_2 to metal, was initiated at about 380 C and was not strongly exothermic. Time required for completion of the second reaction (measured by hydrogen uptake) was 50 minutes at 400 C and 30 minutes at 500 C.

Advantage is being taken of the availability of pure technetium to prepare analytical standards, which will be distributed to all interested Hanford Laboratories for calibration purposes.

EQUIPMENT AND MATERIALS

New Dissolver for NPRF

A design for a new dissolver for the Plutonium Reclamation Facility (Project 880) was nearly completed this month. The new design provides for better thermal circulation within the dissolver and also will allow the changing of acid and nitrogen entry points as required to prevent solids deposition which plugged the existing dissolver. Increased surge capacity is provided to reduce the probability of carryover into the condenser and product.

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Non-Metallic Materials

A vitreous carbon crucible, mentioned last month as a possible fused chloride container, failed by oxidation damage at less than 70 hours in air at 900 C. A similar crucible containing equimolar NaCl-KCl was held at 900 C in an argon atmosphere for 96 hours. A very small amount of the chloride mixture had penetrated the crucible. The crucible suffered a weight loss of 2.3 percent.

Samples of two bearing materials, Carbon 41 and Ebolon (a carbon-filled TFE produced by Chicago Gasket Company), taken from Chempumps, were judged not satisfactory for service in hot, concentrated nitric acid. After 240 hours in boiling 60 w/o HNO_3, both showed significant swelling.

Corrosion of 304-L Stainless Steel During Thoria Processing

Liquid phase corrosion rates for 304-L stainless steel in boiling thoria dissolvent [13 M HNO_3-0.01 M HF-0.03 M $Al(NO_3)_3$] decreased from 2.8 to 1.4 mils/mo as aluminum concentration was increased from 0.03 to 0.25 M. Vapor phase corrosion rates were very nearly the same. Under heat transfer conditions (140 C bulk metal temperature) liquid phase corrosion rates decreased from 4.4 to 2.6 mils/mo over the same aluminum concentration range. In the terminal dissolver solution [1 M $Th(NO_3)_4$], liquid phase corrosion rates were about 0.2 mil/mo at boiling and 2 mils/mo under heat transfer conditions. Aluminum to fluoride mole ratio effects are overshadowed by the high concentration of thorium. Average corrosion rates at boiling point were about 5 mils/mo liquid phase and 1 mil/mo vapor phase during three-fold concentration of the terminal solutions over 30- to 50-hour periods. During similar concentration of terminal solutions, in which excess nitric acid had been destroyed with sugar, average liquid and vapor phase corrosion of 304-L was less than 0.5 mil/mo.

PROCESS CONTROL DEVELOPMENT

AC Column Facility

All minor construction work necessary before installation of the computer van has been completed. The installation of the signal wiring from the control room to the van area was completed. A system was constructed to simulate control signals that would come from the process control computer. Startup and steady-state operation of the AC facility under simulated computer control was then demonstrated to be satisfactory.

C-Column Mathematical Model Development

A new approach is being attempted in order to obtain solutions to the large matrix equation which arises in the solution of the non-linear C-

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column model (ref: HW-SA-3484). The approach uses an iterative technique called the "conjugate gradient" method. A reasonably good initial approximation to the solution of the matrix equation is obtained by using a linear C-column model with average values substituted.

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REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process Engineering Development

Experiments in the High Level Radiochemical Facility were continued during the month in an attempt to precipitate 99 percent of the plutonium after which the uranium and the rare earth fission products would be electrodeposited. Sparging the molten salt bath with pure oxygen resulted in the precipitation of only 92 percent of the plutonium initially in solution and an apparent limiting concentration of 0.01 w/o plutonium was reached. Electrolysis under codeposition conditions was attempted in hopes of leaving the previously precipitated plutonium undissolved. The electrolysis did not remove the plutonium from solution as expected, and a major portion of the previously precipitated plutonium was redissolved.

In other work, the oxidation of U(IV) with a 3 l/min O_2 - 1/2 l/min Cl_2 sparge at 550 C in equimolal KCl-LiCl was determined to be linear with time at a rate of 0.22 w/o per hour in pilot plant equipment. The plutonium oxidation rate is reported to be about one-half the U(IV) rate in laboratory scale equipment. Hence, adequate plutonium enrichment in the UO_2 deposits should be attainable in the C-cell equipment if a similar relation between U(IV) and plutonium oxidation rates exists on the large scale.

Photometric Measurement of Uranium(IV) in Chloride Melts

A photometer sensing unit, comprised of a tungsten-filament light source, a quartz light pipe, a filter, and a CdS photo-detector, was constructed for use in estimating the uranium(IV) content of molten chloride salt melts, a matter of some concern in the Salt Cycle Process. The photometer has been tested in the 321-A Building Salt Cycle facility with good results. With the effective cell length used (one-half inch, determined by the length of the gap in the light pipe which is inserted into the melt), the photometer was found to be sensitive to uranium(IV) over the concentration range of 0 - 2 weight percent. This instrument should be of help in determining the readiness of Salt Cycle melts for the various uranium and plutonium recovery steps.

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RADIOACTIVE RESIDUE PROCESS DEVELOPMENT

Coupled Spray Calciner - Continuous Melter

Development work continued using as feed a simulated, sulfate-free Purex waste with colemanite added as a flux. Product from the 14-inch spray calciner with a draft tube was served as feed powder to the 10-inch continuous melter.

A 48-hour run was completed successfully at calciner feed rates from 3 to 8 gph. Some wall deposits of compacted but unsintered powder were evident, but they did not affect completion of the run. The continuous melter, operated at a wall temperature of 950 to 1000 C and a melt temperature of 850 to 900 C, produced 121 pounds of "glass" melt. The siphon overflow valve delivered the glass by application of vacuum to initiate transfer. In other runs, the tendency toward wall deposit formation was studied. It was found that they are not a direct function of high feed rates to the calciner.

Spray Calciner

The 14-inch spray calciner was operated without the continuous melter to study operation without a draft tube. Purex sulfate-free simulated wastes at 4 gph produced only light wall deposits.

Glass Viscosity Measurement

The viscosities of two glass samples were measured in a temperature range of 800 C to 1000 C. The samples were a Redox borosilicate glass and a Purex colemanite glass. The viscosity curves for the two samples were greatly different over this temperature range. The borosilicate glass had a slightly lower melting point (below 700 C) and the viscosity dropped more gradually over the entire temperature range showing a span from 147 poises at 780 C to 28 poises at 975 C. The Purex colemanite glass melted between 750 and 800 C; the viscosity dropped very fast the first few degrees above melting, showing 65 poises at 830 C, 24 poises at 875 C and then gradually leveling out at the higher temperatures to 8 poises at 1025 C. The viscosities of the two glasses were the same at approximately 820 C.

Waste Melter Pot Materials

Sulfate-containing melts were the most severely corrosive to 310 stainless steel among a variety of melt compositions tested at 950 C; rates as high as 2 mils/mo were noted. When ferric was added to a melt prepared from calcined Purex waste with added solid colemanite, the

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corrosivity of the melt to 310 stainless steel was reduced by a factor of about 50. However, if the colemanite was added before calcination, subsequent addition of ferric oxide had no effect on the corrosion rate. No explanation is apparent for these results.

A 50 Cr - 50 Ni alloy corroded at 11 mils/mo during exposure (24 hours) at 1100 C to a Redox waste-colemanite melt. In a Purex waste-colemanite melt at 950 C, the corrosion rate was about 2 mils/mo; with added NaH_2PO_4, the corrosion rate was at least 2 mils/hr. A 50 Ni - 50 Cr containing 1 percent titanium can be made quite ductile by a one-hour heat treatment at 1200 C followed by rapid cooling. Air cooling would probably be adequate, but water quenching would be better.

Data Logger for Waste Solidification Engineering Prototype

A 7090 program has been written to process the data obtained from the WSE prototype by means of the automatic data logger. The program converts instrument readings to engineering units, computes functions of many readings and prints out the results in report form. Plots of many of the reduced variables are also prepared using Electronic Data Processing Operation's digital plotter.

Continuous Glass Studies

In-cell installation of equipment for full-level testing of the Brookhaven continuous glass process was virtually complete at month's end. "Hot" operation will begin in September. Comprehensive supporting laboratory studies of the effects of composition on the phosphate glass system continued.

Initial hot-cell continuous glass runs will be in a sense "pot" runs, with the glass collecting in the Brookhaven-provided platinum-lined Inconel 702 melters. One of these will be used (and sacrificed) for each run, unless use of a removable ceramic crucible liner proves feasible. A drawback to this type of operation (with or without a liner) is that average hold-up time will be much longer than in a truly continuous unit. The laboratory studies show that degree of loss of sulfate and phosphate, extent and type of phosphate bonding, and resulting glassiness of phosphate glasses are strongly influenced by thermal history. A heavy-wall continuous platinum melter is being fabricated for later installation. A thin-walled, Inconel-backed, continuous melter failed catastrophically during "cold" testing. Apparently the glass penetrated a pin hole in a faulty weld. In the ensuing, extremely violent reaction, the phosphate is believed to have been reduced to elemental phosphorous which attacked the platinum. Product of the thermite-like reaction was globules of an alloy which X-ray analysis showed to be about 45 percent platinum and the rest nickel.

Intermediate Level Waste Treatment

The bacteria count in Purex alkaline waste condensate samples taken from the receiver tank at different times was determined. The number of viable cells varied from none detectable to 10^4 cells/ml. The samples were stored at low temperature to prevent further growth until the count was determined. Samples which had no detectable bacteria at the time of sampling show 10^3 cells/ml after 48 hours at room temperature and 10^4 cells/ml after 120 hours. The cause for the day to day variation in bacteria count at sampling time has not been resolved. The concentration of bacteria present in the fresh samples is thought to be too small to cause plugging of ion exchange beds since about 10^6 cells/ml are required to produce turbidity in water. However, the growth of bacteria in the condensate during storage can definitely complicate subsequent treatment by ion exchange.

CONTAINMENT SYSTEMS EXPERIMENT

Major Facilities and Equipment

Decontamination continued in T-Plant to reduce contamination levels to values below Radiation Protection control limits. Maximum background dose rates less than 5 mr/hr appear to be attainable.

Drawings for the containment vessel were received from the Chicago Bridge & Iron Company and are being reviewed. The vendor requested and was granted an extension of 35 days in the scheduled completion date because of delays in steel delivery. Struthers-Wells submitted a negotiated price of $131,000 for the reactor simulator vessel. Various details of their proposal are being reviewed.

Fission Product Simulation

A 50 kw Lepel high frequency generator was received and installed in 271-CR Building for use in the fission product generation demonstration study in support of CSE. During the acceptance tests, a stainless steel clad UO_2 specimen measuring 1/2 inch in diameter by 3 inches long was heated to the UO_2 melting point in about 2 minutes. Additional tests are in progress to familiarize personnel with the operating characteristics and capacities of the equipment.

General

The CSE program document has been reviewed and is being revised to incorporate comments prior to formal issue.

[redacted] [redacted]

BIOLOGY AND MEDICINE - 06 PROGRAM

TERRESTRIAL ECOLOGY - EARTH SCIENCES

Hydrology and Geology

The electronic equipment used for measuring degree of soil sample saturation (measurement of unsaturated flow parameters) is undergoing repair due to a needed revision of the discriminator-amplifier section. Correction of this difficulty should result in more stable readings of transmission of the Am-241 source photons.

Analytical functions used to fit soil parameters give diffusivity values very comparable to the values determined by graphical handling of the data. The results of predictions of horizontal, linear, transient flow are quite similar for the two methods of handling the data. The utility of the functions appears to be in the ease of programming and data input preparation.

RADIOLOGICAL AND HEALTH CHEMISTRY

Multidimensional Coincidence Spectrometry

Co-60, Ru-106, Ce-144 and Ra-226 were measurable in the salts from 12 liters of ocean water obtained for us by Oregon State University from a location 50 miles west of Newport, Oregon. Na-22, Sc-46 and Th-228 were present but could not be determined with precision. If the salts from 50 liters of water were used with our large 9-3/8 inch diameter crystals, all of these radionuclides should be measurable. Samples of salts from this water and from water taken at a 300-foot depth are being neutron activated to demonstrate the ability of the multidimensional coincidence spectrometer to determine directly some ten of the trace elements present.

Bass muscle from a fish caught in the Columbia River was found to contain measurable quantities of Na-22, K-40, Sc-46, Mn-54, Co-58, Co-60, Zn-65, Cs-134 and Cs-137. The Cs-134 to Cs-137 ratio was observed to be about 0.05, which is more than an order of magnitude higher than the ratio observed in other foods not obtained from the Columbia River.

Large Area Alpha Spectrometry

The large area alpha spectrometer was operated successfully this month with a resolution of 140 kev. High backgrounds obtained with the commercially obtained, aluminum coated, plastic source mounts must be reduced before very low-level counting can be done.

[redacted] [redacted]

Radionuclides in Human Hair

Sixteen hair samples from Alaskan Eskimos of Ahnaktuvuk Pass, Alaska, were found to contain Cs-137 in concentrations ranging from 1 - 8 dpm per gram of hair. When normalized to their Cs-137 body burdens obtained through whole body counting by Radiological Physics personnel, the results were 3 - 8 dpm per gram of hair per microcurie of Cs-137 body burden. This range is surprisingly small considering the probable non-uniformity of hair sampling. Further hair sampling will be undertaken to obtain better values correlating hair concentrations with Cs-137 body burdens.

ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Aerosol Sampling Study

Studies of the apparent inertial effects of zinc sulfide particles on their collection upon the 41 mm diameter filters were continued for air sampling rates much lower than isokinetic. Runs were completed for a sampling flow rate of 0.014 of isokinetic at a windspeed of 16.5 mph and for an impaction sample at 9.0 mph.

Analysis of the data for 16.5 mph leads to the conclusion that calculated concentrations from the subisokinetic filter would be 1.2 to 5.7 times greater than the true concentration for particles from respectively 3 to 25 microns in diameter.

The reproducibility of the samples taken at two adjacent positions in the wind tunnel with an air flow of 9.0 mph was determined. For size ranges between 12 and 25 microns, the reproducibility was 636 vs. 612 and 144 vs. 135 particles on each filter, which is considered excellent. Analysis of the impaction data using the same sample locations and 9 mph windspeed showed that the impaction efficiency, N/N_o, increases from

[redacted]

Aerosol Transport, Deposition and Re-entrainment

Monodisperse silica particles traced with Rhodamine-B were much less effectively deposited in 90° tube bends than were methylene blue particles in earlier experiments using comparable flows. The possibility of the near 5 μ silica particles having a superficial density much less than the actual density of silica is being investigated. A Millikan cell was placed in operation to measure charge/mass ratios for these and other particles.

Fallout Studies

The cosmic ray-produced radionuclides S-38 and Cl-38 were measured for the first time in rainwater samples this month. Since 1955 when P-32 was found to be present in rainwater as a result of cosmic ray spallation of argon-40, Cl-39, S-35, P-33, Na-22 and Na-24 have also been reported. Estimates of the expected production rates of other possible spallation products showed that S-38 (2.9 h) should be present together with its daughter, Cl-38, which should be present not only from decay of the parent, S-38, but also as a primary spallation product. The Cl-38 decay mode includes emission of gamma rays in cascade so that it is suitable for measurement by multidimensional coincidence spectrometry. By counting the Cl-38, allowing this material to decay, and later counting the Cl-38 formed by decay of the S-38, measurements of the concentrations of these two radionuclides were obtained. Values obtained from five rain samples were 4 - 13 dpm per liter for S-38 and 9 - 147 dpm per liter for Cl-38. Studies of these radionuclides should increase our understanding of fallout, rainout, and cloud formation mechanisms.

ISOTOPES DEVELOPMENT - 08 PROGRAM

Promethium Heat Source Development

The first measurements of compatibility of proposed promethium heat source core forms with a variety of clads were completed during the month. Two types of experiment were formed. In one, specimens of several candidate canning materials (Hastelloy-X, Hastelloy-N, Hastelloy-C, Inconel-61, Haynes-25, platinum, Rene-41, Carpenter-20, 310 SS, titanium and tantalum) were sealed in evacuated quartz ampoules with samples of cerium, samarium or neodymium metals (stand-ins for promethium metal) and then heated for 550 hours at 1100 C (above the melting point of the rare earth metals). Visual and metallographic examination showed tantalum to be completely unaffected. Titanium was next most inert, whereas the others showed more or less general alloying or leaching-type attack. In the other study, neodymium oxide (stand-in for promethium oxide) and samples of several cladding materials (310 SS, molybdenum,

platinum, Haynes-25, and Hastelloy-N, -X, and -C) were pneumatically impacted (in a SS can), held at 1100 C for 1000 hours, and then sectioned and examined. No attack was visible in the case of any of the materials. Metallography has not been completed. Neodymium fluoride was also prepared and loaded into impaction containers with clad samples for similar exposure.

In other work, NdF_3 was successfully reduced (by reaction with lithium) to a high purity metal button, and design was completed of the promethium reduction equipment which will be installed in the shielded promethium glove boxes.

for Manager
Chemical Laboratory

MT Walling:cf

[redacted]

BIOLOGY LABORATORY

A. ORGANIZATION AND PERSONNEL

W. W. Roberts transferred from Technical Information to the Biological Analyses Operation as an Analyst on August 3.

A. M. Harty, Biological Technologist in Biological Analyses Operation, was temporarily removed from the payroll due to illness absence.

Capt. J. L. Murray, USAF, completed his period of training on August 13, having been assigned to Biology since July 26, 1963. His new tour of duty will be with the AEC's Division of Biology and Medicine in Washington, D.C.

J. E. Ballou, Biological Scientist in the Metabolism Operation, began his Educational Leave of Absence on August 14. He will be working for his Ph.D. at the University of Rochester.

K. R. Price, AEC Fellow, completed a fourteen-month assignment with Radiocecology on August 21, conducting thesis research. He will be teaching at the University of Nevada in Reno.

J. J. Reardon, Summer Professor in the Metabolism Operation, completed his summer assignment on August 21. He will begin a new teaching assignment at the University of Toronto in Canada.

C. W. Fort, AEC Radiological Physics Fellow, completed nine weeks of training with Aquatic Biology on August 28.

C. R. Watson, AEC Fellow, completed his assignment with the Exptl. Animal Farm on August 28.

D. O. Wilson, Biological Scientist in the Radioecology Operation, resigned effective August 28 to return to school. He will work toward his Ph.D. at the University of California, Davis, Calif.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 02 PROGRAM

Reactor Effluent Monitoring

Young chinook salmon reared for 10 weeks on Zn^{65} free diet in reactor effluent concentrations of 0, 2, 4, and 6% accumulate on the average 5, 12, 15, and 9 pc/g fish, respectively. The 6% group compared against the 4% group has about 40% less Zn^{65}. On the other hand, when the effluent is cooled to river water temperature the Zn^{65} concentration was 5, 13, 12, and 19 pc/g fish for 0, 2, 4, and 6% groups, respectively. The results show the importance of even a few degrees increase in temperature on the accumulation of Zn^{65} directly from the effluent water.

Columnaris

Production of antibodies was measured following intraperitoneal and subcutaneous injections of heat-killed columnaris cultures singly and in combination with Freund's adjuvant. Antibody production was greater in trout receiving subcutaneous injections than those receiving intraperitoneal, and in those treated with the adjuvant.

BIOLOGY AND MEDICINE - 06 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Strontium

A 4½-year-old female miniature swine that had ingested 25 μc Sr^{90}/day for approximately 3-3/4 years was killed due to her deteriorating physical condition. Prior to death, she was shown to have a marked elevated leukocyte count. This was due in large part to an increased number of immature polymorphonuclear cells. The predominant cell was a basophilic type myelocyte. On necropsy, marked enlargement of the hepatic and lumbar lymph nodes was observed. The spleen was moderately enlarged. Although not markedly involved, the liver did have an appearance suggestive of its involvement in the disease process.

Tentatively, this has been diagnosed as a case of myelogenous leukemia, probably of a basophilic type. Leukemia of this type is rare in swine and would suggest that this case was related to the radiation exposure of the animal. The accumulated radiation dose to the bone marrow of this animal was estimated at—3000 rads at a minimum.

This case is of particular interest since this is the first clear-cut indication of radiation damage in an animal on the 25 μc Sr^{90}/day regimen.

Iodine

In order to study the early gastrointestinal movement and absorption of iodine in the ruminant, lambs were given a feed pellet containing 200 μc I^{131} with a balling gun and then euthanatized at intervals. Preliminary results indicate a detectable I^{131} level only as far as the omasum (or third portion of the ruminant "stomach") in 10 minutes. Although I^{131} could not be detected in the blood at 10 minutes, it could be in the thyroid, where the I^{131} seemed to be about the same as in the rumen. Detectable concentrations appear in the duodenum by 20 minutes and in the colon by 40 minutes. (This work will be expanded to incorporate whole-body monitoring and the use of an unabsorbed tracer to compare with the GI movement of I^{131}.)

Cesium

Thermoluminescent dosimeters (containing LiF) were surgically implanted in three male sheep that were fed 25 μc Cs^{137}/day for extended periods of time. Additional dosimeters were attached to the exterior of the animal. After a 15-day exposure period for the internal dosimeters, the animals were killed, the dosimeters recovered, and tissues obtained for Cs^{137} analysis.

The dosimeter capsules used to hold the LiF powder were fabricated especially for this experiment. They are made of teflon and have a 4 mm wall thickness to shield the dosimeter powder from β-irradiation. The β-radiation dose rate to the tissue will be estimated from the Cs^{137} concentration in tissue. The total radiation dose rate to the tissues will be deduced from the calculated β dose and the gamma radiation dose rate measured with the LiF.

Complete results of this study and a comparison with work performed in this laboratory several years ago using a less elegant system will be available next month.

Rumen sampling of three rumen-fistulated Suffolk ewes is being conducted over a period of 18 days. Daily feeding of each ewe consists of 1 kg chopped alfalfa hay spiked with 25 μc Cs^{137}. The sampling times are just before feeding and 7 hours following feeding. The Cs^{137} concentration of the pre-feeding samples on the second day were one-half that of their spiked feed while the concentration of the rumen content on the afternoon sample exceeded the concentration of their daily feed. (This latter phenomena has been described by Radioecology in reindeer and caribou in Alaska.)

Plutonium

Desferrioxamine-B (DFAB), when given at the same time as DTPA, was better for removing well-deposited Pu^{238} from rats than either agent alone, or when DFAB and DTPA were given on alternate days, or when given with phenylbutazone. No statistically valid difference between the control and any treatment value for bone Pu concentration was found so that the total effect was in the soft tissues. The extra Pu excreted by the treated animals came out with the urine and their was no increase in the fecal plutonium output.

Inhalation Studies

Plutonium analyses were completed on a dog that died 51 months following a single exposure to $Pu^{239}O_2$. The body burden at death was 1.3 μc: 51% in lungs, 41% in bronchial and mediastinal lymph nodes, 3% in liver, and 4% in skeleton. Cardiopulmonary insufficiency and lymphopenia were the primary clinical signs prior

to death. Histopathology showed fibrosis and metaplasia in the lungs and fibrosis in the bronchial lymph nodes, but no primary tumors. However, four of the nine dogs that have died 2 to 4 years after exposure to $Pu^{239}O_2$ had primary pulmonary tumors.

Two dogs were sacrificed six months after exposure to $Ru^{106}O_2$. Total body scans with the dog counter indicate that the body burden of Ru^{106} is almost entirely in the lung region. This is in contrast to the dogs exposed to $Ce^{144}O_2$ which appears to be retained in both lung and liver areas.

In studies of lung tissue homogenates the synthesis of fatty acids by rabbit lung mitochondrial fractions was only one-fourth the rate found in similar preparations of rat lungs. This further example of species differences is disappointing in that it was hoped that rabbits would provide an economical source of lung tissue for our biochemical studies.

During the past year 116 puppies were whelped in the dog colony. The mean litter size was 5.8 puppies per litter, mortality 8%, and 5.3 puppies were weaned per litter. The litter size is greater and the mortality substantially less than reported for other experimental dog colonies. Because of the success of the breeding program in providing the animals required for experiments planned in 1965 further breeding will not be necessary during the next six months. To house the expanded dog colony this winter, most of the existing dog runs are being divided and an additional 20 temporary runs are being constructed. Occupancy of the 60 dog runs in the 300 Area next spring will be required to house the dogs as they are assigned to experiments.

Gastrointestinal Radiation Injury

A radiomimetic nitrogen mustard was even more effective in preventing bile salt absorption than X-irradiation, when compared on a comparable mortality dose basis. One and 2 mg/kg of methyl-bis(2-chloroethyl)amine hydrochloride (HN2) depressed bile absorption in rats by 40 and 88%, respectively, three days after injection, while the lethally equivalent X-ray doses of 1,000 and 1,500 r to the abdomen caused only a 10 and 53% depression below normal.

Secondary Disease Studies

Non-treated LAF mice and mice irradiated with 950 r of X-rays were given 2×10^7 cells of rat bone marrow or spleen. The liver parenchymal cells of the chimeras were examined in the microspectrophotometer 1, 3, 7, 10 and 14 days after the injection. Normal liver parenchymal cells of LAF mice are made up of two ploidy classes based on a DNA classification, diploid and tetraploid, however, no dramatic changes in ploidy were observed in our cytophotometric analyses. This is in contrast to the conclusions of Congden and Kretchmar, based on histological evidence, who felt that the symmetrical enlargement of the chimera's liver was due to an increase in ploidy causing an enlargement in the individual cells.

Plant Nutrition

Experiments were begun to study iodide transport in barley plants under conditions of diminishing energy substrates. Initial tests showed iodide transport (1) stopped during dark periods following a photo period, and (2) was enhanced by chloramphenicol. Both results are contrary to expected results and are being investigated further.

Microbiology

Tryptophan mutants exhibit considerable growth after tryptophan has been exhausted from their filtrates. This growth was previously believed to occur at the expense of an intracellular pool of tryptophan; however, experiments conducted upon this amino acid shortly before and shortly after its disappearance indicate the growth is made at the expense of some metabolic product of tryptophan which is excreted into the medium and re-assimilated. Several experiments, both in vivo and in vitro, are now in progress to identify the compound, believed to be indolepyruvic acid - the α-keto acid corresponding to tryptophan.

Radiation Effects on Insects

Flour beetles maintained at various temperatures following X-irradiation showed (1) delayed reproductive onset and reduced productivity in females given 4000 r; (2) a possible synergistic effect of lower temperature combined with dosages of 2000 r or 4000 r; and (3) females were more sensitive to irradiation than males, as measured by fertility and productivity of irradiated adults. Dose-response curves were of the "multi-hit" type, indicating radiation-induced chromosomal aberrations as the major cause of altered productivity.

Effects of X ray on Fish

Three groups of cichlids exposed to 2000 r and reared at three different water temperatures of 20, 25, and 30 C for 60 days showed no difference in growth at the lower temperatures, but the irradiated group in 30 C water was smaller at the 1% level of significance. Controls averaged 11 $\pm$ 5 g compared to 8.8 $\pm$ 3 g for the irradiated groups. No significant mortality occurred between treatment groups.

Effects of Water Temperature on Fish

Fish acclimated at 18 C had significantly different respiratory rates for red and white muscle. The Q_{O_2} (N) for red muscle is 1.24 $\pm$ 0.11 as compared with 0.824 $\pm$ 0.15 for white muscle. This difference is also seen in their utilization of labeled intermediary metabolites in vitro. The red muscle is the much more metabolically active of the two tissues at this temperature as it will produce 14.4 pc CO_2/mgN/hr from C-1 glucose, 1.88 pc CO_2/mgN/hr from C-6 glucose and 12.71 pc CO_2/mgN/hr from acetate. The white muscle produces 6.9 Gl_1, 1.13 Gl_6, 4.28 AC_1, respectively.

Columbia River Limnology

Statistical analysis of periphyton biomass measurements showed best correlations were between dry weight, ash weight, and chlorophyll a content. Net production rate was closely correlated with chlorophyll a and solar radiation, and varied from 10 to 140 μg dry weight/cm^2/day. Phosphorus-32 and zinc-65 accumulation also correlated best with dry weight, ash weight, and chlorophyll a.

Radionuclide accumulation by periphyton varied independently from the radionuclide burden of the river.

These data suggest that adsorption is the dominant mode of radionuclide uptake by the river periphyton community.

Terrestrial Ecology

Cation analyses of cheatgrass harvested from beneath greasewood and hopsage canopies and from intershrub areas showed: (1) potassium content highest in plants grown beneath hopsage and greasewood and lowest in those from open areas, and (2) sodium content highest in plants harvested from beneath greasewood and lowest in those from open areas. These data illustrate the influence of selective cation accumulation by desert shrubs upon mineral accumulation by associated plants. The importance of such environmental alteration upon radionuclide uptake was illustrated in laboratory experiments with soil taken from beneath greasewood canopies. Cesium-137 uptake by barley plants grown in such soil was fairly consistent; however, Sr^{85} uptake was much reduced compared to other soils, presumably because of the high pH (9.1) and an abundance of sodium.

Alaskan Studies

Whole-body counting was continued at Arctic Village and Kotzebue. Average Cs^{137} body burdens at these locations were 640 and 340 nanocuries, respectively. Current values are approximately double those observed one year ago. Corrected values for 27 Anaktuvuk Pass natives counted during all years were 1250 nc (average) and 2400 nc (maximum). A maximum Cs^{137} body burden of 3000 nc was detected in a non-native resident of a river village, of which native residents contained an average of 360 nc and a maximum of 670 nc. This high Cs^{137} burden resulted from much greater caribou consumption than most natives of the same location.

Caribou flesh obtained from Anaktuvuk Pass during March and May contained 110 and 190 pc Cs^{137}/g dry weight, respectively. This is twice the concentration observed one year ago.

Samples were obtained in lichen plots to which Sr^{85} and Cs^{134} were applied last month.

H A Kornberg

Manager
BIOLOGY LABORATORY

HA Kornberg:es

TECHNICAL INTERCHANGE DATA
BIOLOGY LABORATORY

I. Speeches Presented

a. Papers Presented at Society Meetings and Symposia

Bustad, L. K. Significance of radionuclide contamination in ruminants. Second International Symposium on the Physiology of Digestion in the Ruminant. Ames, Iowa. August 19-21, 1964.

Cushing, C. E. Productivity and radionuclide accumulation of periphyton in the Columbia River. AIBS Meetings - Ecological Society of America, Boulder, Colorado. August 23, 1964.

Rickard, W. H. Mineral uptake by greasewood and hopsage. AIBS Meetings - Ecological Society of America, Boulder, Colorado. August 23, 1964.

Nakatani, R. E. Toxicity and metabolism of zinc-65 in trout. AIBS Meetings - Ecological Society of America, Boulder, Colorado. August 26, 1964.

Clarke, W. J. Histopathology and autoradiography of the canine following plutonium inhalation. Pacific Northwest American Industrial Hygiene Association, Richland, Washington. August 28, 1964.

Palotay, J. L. Anatomy and physiology of the mammalian lung. Pacific Northwest American Industrial Hygiene Association, Richland, Washington. August 28, 1964.

McClellan, R. O. Ectopic myelopoiesis and other hematologic changes in miniature swine ingesting Sr^{90} daily. Xth Congress of the International Society of Hematology, Stockholm, Sweden. August 30-Sept. 4, 1964.

b. Seminars (Off-Site and Local)

University of Washington Summer Institute in Radiation Biology, Richland, Washington:

August 12, 1964

Mahlum, D. D. - Heavy Metals and Liver Metabolism

Bustad, L. K. - Radioiodine in Farm Animals

McClellan, R. - Sr^{90} Metabolism in Pigs

University of Washington Summer Institute - Continued:

August 14, 1964

Hanson, W. C. - Alaskan Studies

Park, J. - Inhalation of Radioactive Particles

Nakatani, R. E. - Effluent Monitoring and Fish Research

Erdman, H. E. - Radiation Studies with Flour Beetles

c. Seminars (Biology)

None

d. Miscellaneous

None

II. Articles Published

a. Open Literature

Rickard, W. H. Demise of sagebrush through soil changes. BioScience 14, No. 8: 43-44 (1964).

b. HW Documents

None

III. Visits and Visitors

a. Visits to Hanford

Thirty members of the University of Washington Summer Institute in Radiation Biology toured Biology and listened to lectures on August 12 and 14.

Dr. Rajendra Sachdev of the AEC in Bombay, India, toured Biology on August 13, 1964.

Dr. F. N. Dost of Oregon State University, Corvallis, Oregon, conferred with Dr. W. J. Clarke on problems of radiation on August 28.

M. Tembreull of the University of Washington discussed bio-engineering problems with Dr. Clarke on August 31.

b. Visits Off-Site

6/27 - 8/10 - W. C. Hanson conducted biological studies in Alaska.
8/5/64 - F. P. Hungate and D. G. Watson attended a Columbia River Studies Meeting at Oregon State University, Corvallis, Oregon.
8/6/64 - J. Hsieh obtained soil conditioner from the U.S. Dept. of Agriculture at Prosser, Washington.
8/7-11/64 - H. A. Kornberg attended a meeting in Aspen, Colorado, sponsored by Battelle Memorial Institute to discuss institute-sponsored research.
8/10-12 - R. O. McClellan attended a meeting held by the Division of Biology and Medicine, U.S. AEC in Washington, D.C.
8/11/64 - L. L. Eberhardt and W. H. Rickard collected fallout samples at Packwood, Washington.
8/15-9/13 - R. O. McClellan will be discussing research with RJ Garner and J. Rundo at AERE, Harwell, England; RA McCance and EM Widdowson at the Medical Research Council, Dept. of Medicine, Univ. of Cambridge; L. M. Van Putten at the Radiobiol. Inst. of the Organization for Health Research, Rijswijk, Netherlands; and presenting a paper at the Xth Congress of the Insternational Society of Hematology, Stockholm.
8/17-24 - L. K. Bustad presented a paper at the Second Intntl. Symposium on the Physiology of Digestion in the Ruminant at the National Animal Disease Center, Ames, Iowa and conducted library research at the University of Washington in Seattle.
8/23-29 - R. L. Uhler and J. M. Dean attended AIBS Meetings in Boulder, Colorado.
8/23-29 - C. E. Cushing, W. H. Rickard, and R. E. Nakatani presented papers at the AIBS Meetings in Boulder, Colorado.
8/24/64 - L. L. Eberhardt collected fallout samples in Dayton, Wn.

IV. Achievements

None

V. Honors and Recognitions

None

VI. Professional Group or Organization Assignments

None

APPLIED MATHEMATICS OPERATION

MONTHLY REPORT - AUGUST, 1964

ORGANIZATION AND PERSONNEL

B. B. Field, Manager-Operations Research, transferred to Business Planning and Transfer Operation effective August 1, 1964.

J. L. Sanders, a summer professor, left on August 27 to return to the University of Arizona.

ACTIVITIES FOR OTHER HAPO COMPONENTS

N-Reactor Department

A procedure was formulated regarding sample sizes necessary to ensure pre-specified power in testing the difference between two means.

Experimental data were employed in the development of equations (with confidence intervals) to predict the underwater weight of fuel elements (both inner and outer) from the weight in air.

Irradiation Processing Department

Research and Engineering

The study of the validity of in-reactor sector gauge measurements of process tube thickness was continued.

Several run-to-rupture tests were designed comparing the AlSi and HDS processes for different amounts of uranium enrichment. Careful statements of the null and alternate hypotheses to be tested were made in view of the dollar incentives to use the HDS process if reactor performance is comparable to the AlSi process. The number of tubes to be used in the test, the percentile points where the first and last ruptures can be expected, and the power curves for the tests were also submitted.

Work is continuing on the analysis of production test PT-546A, which compares the dimensional distortion behavior of HDS and AlSi fuel elements.

Manufacturing

A study has been completed of the reliability of the zone temperature monitoring system which includes all of the components which are required to respond on demand in a scram system. Confidence limits have been calculated on the reliability of the system based on sampling results of the components. Graphs have been prepared which indicate the effects of the various component reliabilities on the systems. Further graphs and tables give the expected number of incidents which would not be detected on the average as a function of the mean number of incidents a year.

An approximate formula for χ^2 percentile value has been used to calculate the 1%, 2.5%, 5%, 10%, 90%, 95%, 97.5%, 99% points for a range of over 100 degrees of freedom. These values are to be used in conjunction with the determination of confidence limits on individual component reliabilities.

Production Fuels

An end-bonding test for the HDS process was designed where the factors are the control temperature, the power time, the post-power time, the pressure and the presence or absence of a wafer in the cap end.

Production test PT-IP-684-A compares six different canning treatments. An analysis of the extensive dimensional and weight measurements made preliminary to irradiation has been made. The results compare the six treatments for 22 different dimensional statistics. Confidence limits and tolerance statements were also determined. An analysis similar to this was also done for the fuel elements in production test PT-IP-708-A which also compares six treatments.

A test design to study the effects of aluminum, silicon and iron impurities and the quenching method used in the fabrication of uranium on the dimensional distortion effects under irradiation has been submitted to interested personnel.

Components of variance of the UT-2 values were estimated for differences arising due to the ingot, fuel element type, and individual fuel element sources of variation.

The between parts, between locations within a part, and measurement components of variation were estimated for several types of X-ray determinations and grain orientation variables. The biases and precisions of the types of X-ray determination values were also compared.

A considerable amount of data describing the bonding layer diffusion properties resulting from several HDS canning techniques are being studied.

ACTIVITIES WITHIN HANFORD LABORATORIES

2000 Program

Ground Water Models

EDPM programs were completed which compute three rather complicated mathematical functions that frequently arise in soil physics investigations.

C-Column Computer Control

Documentation continued of functional programs which will be used to control the operation of the C-Column with the GE 412 process control computer.

The final draft was completed of the revision of the paper, "A Data Logging Absorptiometer for Routine Uranium Analysis," which was submitted and accepted for publication in Talanta contingent on revision along the line now accomplished.

Other

A study was initiated to measure the errors in the computational sequence for determining the in-place permeability distribution for heterogeneous soils.

3000 Program

Numerical Control of Rotary Contour Gages

A document, HW-83670, entitled "Sheffield Gage Control Tapes" has been issued. This document explains and illustrates the Fortran language computer program "Sheffield Pulse Increment Gaging" (SPIG). SPIG instructs the IBM 7090 to produce magnetic tapes that control the prototype Sheffield rotary contour gage.

Power-Roll Forming Studies

An EDPM program was completed which computes the contour anomolies to be expected on a power-rolled form as a result of using a blank with known thickness deviations.

4000 Program

Radiation Damage to Fissionable Materials

Documentation was completed of the Fortran language program SALTY which unfolds an observed two-dimensional particle size distribution into its three-dimensional counterpart. Work continued on the formal Hanford report which will include the mathematical development leading up to the SALTY program and a description of the use of the program.

4000 Program (continued)

Other

An analysis comparing the corrosion rates of metals resulting from different welding techniques is being completed.

An analysis was made to determine whether significant differences exist between different locations and measurements made at different time periods in the chemical assays of a casting.

Assistance was given on the mathematical aspects of several thermal diffusion problems being studied in the non-destructive testing program.

5000 Program

Computation and Statistical Analysis

The new version of the GEM program, which provides for 30 nuclides and 100 channel groups, ran successfully. An additional modification is being made to simplify the specification of the model. Work continued on the problem of deciding between the two alternatives; that a set of random times between successive counts arose from the decay of a pure nuclide, and that the times were generated from a uniform intensity background. The problem is being considered both from the standpoint of a random number of counts in a fixed time period and the random time to observe a fixed number of counts.

Radiochemical Analysis

Work on the file maintenance pass of the MUL system or multi-dimensional gamma spectrometer data is near completion. The next pass for this system, a spectrum addition and background correction program, was specified during the month.

Planning of several extensive changes to the IRA master file was started, as the present format and space for much of the data is no longer adequate.

Other

Analysis continued on a mathematical model describing the diffusion of metals into metals.

6000 Program

Biology

An analysis of data was completed relative to the swimming performance of Zn^{65} treated trout.

Computer programs were written relative to a Sr^{90} toxicity study (pig skeleton) and a Sr^{95}-Ca^{45} interrelationship study.

External Dosimetry

External dosimetry data were analyzed so that the excess dosages of β, γ, and X-ray assigned to the Hanford personnel file in 1963 may be estimated.

Carl A. Bennett

Manager
Applied Mathematics

CA Bennett:lg

Programming

Programming Operation has been merged with Physics and Instruments Laboratory and Radiation Protection Operation. These groups are now reporting fuel cycle analysis and nuclear health and safety work, respectively.

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF AUGUST 1964

A. ORGANIZATION AND PERSONNEL

Alta M. Morehouse transferred to Radiation Monitoring as a Secretary, effective August 24, 1964. Emma K. Wilkison, External Dosimetry, terminated August 26. Effective August 17, Fred N. Eichner joined Internal Dosimetry as a Technician, Whole Body Counter. Flordeliz A. Smith, Radiation Monitoring, began her leave of absence on August 28.

B. ACTIVITIES

Occupational Exposure Experience

There were no new plutonium deposition cases confirmed by special bioassay analysis during the month. The total number of individuals who have received plutonium deposition at Hanford is 345. With the termination of three employees and reactivation of one employee, there are currently 243 employed at Hanford.

In August there were two incidents involving four employees which required special bioassay sampling for plutonium analysis. The following is a brief description of the more significant incident:

> Three CPD employees were working in the Plutonium Purification and Fabrication Building (234-5) when a sight glass on a hydraulic cylinder broke in an adjoining room. Plutonium contaminated fluid was sprayed into the room, contaminating the floors to > 40,000 d/m. The employees were exposed to air-borne concentrations up to 6.4×10^{-11} µc Pu/cc for approximately thirty minutes. The analysis results are not expected to indicate significant depositions.

In addition to the incident involving plutonium, there were five incidents involving ten persons that required evaluation for possible intake of other radioisotopes. The following are brief descriptions of the more significant incidents:

> An HL employee in the Radiochemistry Building (325), received cuts on his right index and middle fingers when a glass flask containing Tc-99 broke. Some Tc-99 was detected during an examination at the Whole Body Counter. A preliminary evaluation indicates that the total deposition is < 10% of the maximum permissible body burden of 10 µc, based on kidney as the limiting organ. Special bioassay sampling for Tc-99 analysis has been requested.
>
> Three NRD operators were exposed to air-borne concentrations of Sm-153 while working on the Ball 3X Recovery System in the 105-N reactor. An examination of one of the operators, using the Whole Body Counter, revealed no detectable samarium. Special bioassay samples, obtained

and processed for Sm-153 for all three persons, indicated no detectable deposition.

Intravenous administration of DTPA to increase the amount of plutonium excreted are continuing on the Hanford Laboratories technician who received the plutonium contaminated injury on July 10 while working at the Plutonium Metallurgy Building (231-Z). Additionally, and for the same purpose, intramuscular injections of Desferol are being given along with DTPA. However, no increase in the amount of plutonium excreted has been noted.

Environmental Experience

Efforts to eliminate the radiation problems associated with the cooling water swamps for Purex continued through August. All highly contaminated areas of the "B" Swamp have been backfilled and this swamp is again in good condition. Efforts are continuing to raise the water level in the Gable Mountain Swamp with the application of Bentonite clay. Although the concentration of radioactive materials in the water is now satisfactory, the depth of water over contaminated bottom is not sufficient.

Concentrations of fallout materials in the air of Eastern Washington averaged 0.8 pc β/m^3 during August. This value is slightly lower than the average of 1 pc/m^3 recorded in July and represents a continuation of the slowly decreasing trend noted during the past two months.

Studies and Improvements

A revised heating and ventilation system for the PRTR Storage Basin was designed by Vitro personnel incorporating the comments provided by Radiological Development and Calibrations. The features in the revised design were 10 air changes per hour, an increase in the size of the air filter room to provide for the additional air volume, and exhausting of the air through the PRTR discharge stack.

Studies to summarize radiological measurements related to the Th-232 - U-233 program were documented in HW-83284, "A Comparison of Theoretical and Measured Dose Rates of Thorium and Thorium Oxide." The surface dose rate due to each isotope in the thorium chain was calculated using currently accepted formulas. After corrections were made for the state of equilibrium of the material, good agreement was found between the theoretical and experimentally determined values of surface dose rates. The thorium being processed at HAPO should not present a serious problem with respect to external personnel exposure. Formulas are presented which permit the calculation of an approximate value for the time lapse since the most recent purification. Gamma and alpha energy spectra measurements for the metal and the oxide of thorium presented are in full agreement with those given in the literature.

General adjusting and troubleshooting continued on the new mechanized densitometer. Radio frequency chokes with higher inductance and less resistance than those originally used were received and installed. These improved the noise rejection capabilities of the system. As the noise

interference is intermittent, no statistics can be given to show the degree of actual improvement. A design change in the payroll and tray number reading circuits along with adjustments in the optics enabled the densitometer to read identification numbers off the calibration films as dark as 1,000 mR equivalent. A run was made using the monthly dosimeter film from 100-F and 200-W Areas. Approximately 280 badges were used. The new densitometer read correctly the payroll numbers of more than 99% of the films.

The Richland Water Plant monitor has operated throughout the month of August. As the river flow decreased, some difficulty in keeping the deposit of radionuclides at a minimum was encountered. A ten minute rinse cycle every three hours instead of 15 minutes every twelve hours has greatly reduced the problem. Under a continuing program of obtaining the best possible calibration of the monitor, a Cu-64 sample was obtained and processed through the system. The sensitivity for Cu-64 at the operational discriminator setting of 8.5 volts is about half the average of previously checked nuclides.

New operating instructions for field use of the BFQ neutron monitoring instruments were prepared for distribution. The fluxmeter to dosemeter ratio correction curve was modified to provide improved accuracy in reading in the region most commonly used. Irradiation of a special SbBe source was begun. This source is to be used for checking the instrument's response at neutron energies of about 25 kev. An appropriation request was prepared to authorize the procurement of a number of neutron integrator attachments for the BFQ instruments. These integrators are designed to provide, by use of digital registers, a measurement of the total integrated neutron dose at the instrument's position. It will be several months before off-site fabrication and delivery can be completed.

The plutonium aerosol concentration study of background and low level plutonium locations in the Weapons Fabrication facility was continued by collection of four samples in the radiation monitoring office. Each sample was taken over a one-week period at a constant flow rate of one cubic foot per minute. Semi-quantitative examination by alpha energy analysis techniques identified the plutonium peak and indicated that the air concentration was in the 10^{-14} μc Pu/cc range. This is sufficient activity to permit analysis by the Analytical Laboratory. The initial sample in the series is currently in the Analytical Laboratory and the succeeding samples are being autoradiographed for particle size analysis.

Several thermoluminescent dosimeters were exposed to neutron doses of 1 and 4 rems from PuF_4, and 1, 4, and 8 rems from PuBe. PuBe does not emit as strong a gamma field as PuF_4, and a positive response was observed for all three doses. For PuF_4, the response was positive for just the 4 rems dose. After correcting for absorption by the alcohol, using 0.9 as the absorption factor, all doses showed a positive response.

All of the new CP Meters are now in the portable instrument pool and are being assigned for routine field use. To date, 39 of the old CP's were stripped of useful parts and prepared for excess. Additional CP's will be prepared for excess as they become inoperative. Twenty-five new Juno

Meters were inspected and released by the Portable Instrument Shop and are now awaiting pre-acceptance calibration. Removal of 25 mechanically defective, positive drive Junos from the instrument pool is now in progress. At the request of the local AEC, six Co-60 sources were accepted from the U. S. Army Corps of Engineers and stored in the Calibrations facility for our use or burial.

The 308 Building General Radiation Work Procedure was revised. The most significant change involves dispensing with protective clothing for entries into the building hallways for inspections, tours, and consultations. Protective clothing requirements for entries into the process rooms remain unchanged.

A review was made of three specific areas of 300 Area emergency planning. The following conclusions were reached:

1. Evacuation from the 300 Area, in the event of a criticality, should be by the fastest and most direct route available and without regard to the location of potential sources of criticality accidents.

2. Setting critical radiation detector systems to alarm in a gamma field of 5 R/hour provides adequate assurance that all criticality accidents within 100 feet of the sensing unit will be detected.

3. All facilities within 100 feet of a potential source for a criticality accident should have an extension alarm that would be activated by a detector located near the source.

Capabilities for coping with a serious accident at PRTR were discussed in detail with an engineering firm. This firm is making a comprehensive study of recovery capabilities at 30 reactor facilities at the request of the AEC.

A study was conducted on a past Hanford employee's exposure record to determine the amount of time required to prepare a complete extensive exposure history and to determine the completeness of records available. During the study, which took approximately 2-1/2 to 3 man-months, all the ring and badge dosimeter film from 1944 through 1959 for this employee was obtained, reread and re-evaluated. The records for this employee were complete for his entire employment period.

All selection criteria, based on suffix and job classification code, have been given to Data Processing for programming whole body counter examinations. In addition, the pre-printed IBM schedule cards are now available. Data Processing is currently debugging the program, and they expect to make the first scheduling run for 100-D Area by mid-September. This is one month ahead of schedule. Thus, the automatic scheduling portion of this program is now complete. The final step is the design of a whole body counter data input card on which raw data from whole body count results can be placed on magnetic tape, and from which various types of output reports can be develope..

This effort will be closely coordinated with CDS&R, ES&EO and Industrial Medical to assure that the data input will be of maximum usefulness to the requirements of these organizations as well as IDO.

New standard solutions of both plutonium and uranium have been obtained and analyzed against current standards. Close agreement was obtained in both cases and the new standards have been placed in service.

A complete audit has been made of the first run under the new, automatic plutonium sample scheduling program. The program is based on a frequency determined by suffix and job classification codes. A number of incorrect sample schedule frequencies were detected. Those were due in part to omissions in the initial programming, and in part because of changes of a few job classification codes within CPD and HL. Corrections have been made. However, to keep the selection criteria current, an audit will be conducted every three months to detect improper sample schedules and change the selection criteria accordingly.

Eight employees working in the 3732 Building were measured as part of the routine bi-weekly surveillance program for thorium-232 detection. A slight trace was detected in two individuals.

New equipment consisting of NaI crystals, photomultiplier tubes, and associated electronic gear has been ordered to improve the capability for measuring low-energy gamma or X-ray emitters in wounds. In addition, specialized geiger tubes for location of higher energy beta-gamma contamination in injuries has been ordered. A target date of October 1 has been set for installation of some of this equipment.

Research Studies

Effect of Reactor Effluent on the Quality of Columbia River Water

A study is in progress of the effects of reactor effluent on Columbia River water quality with emphasis on temperature effects. Continuous dye releases for measurement of equilibrium effluent concentrations at downstream locations were made from the upstream reactor areas B, K, N and D. Although the data has not been completely processed, the usual bias toward the plant shore was seen for effluent from all reactor areas as far as the 300 Area.

In order to measure pertinent meteorological parameters more representative of conditions along the river, the portable meteorological station was established on the far shore at White Bluffs. Only the wind and water temperature recorders were in operation by the end of the month. The hygrothermograph needed additional maintenance and the radiometer awaited installation of cable supports.

Mechanisms of Environmental Exposure

An experiment is planned to begin on September 14, in which the uptake and retention of P-32 from Columbia River fish will be measured. The uptake

of P-32 will be measured by a whole body counting technique using a special instrument recently developed in the Radiological Physics Operation. Initially, the P-32 body burden will be determined by a mass balance procedure to confirm the whole body measurements.

Nuclear Facilities Monitoring Guide

Work continued on the guide and several attempts were made to develop a sequential sampling scheme which would reduce to a minimum the number of samples that must be taken and analysed to determine if effluent waste releases do comply with regulatory levels.

C. RELATIONS

There were two minor injuries and no security violations during the month.

Six suggestions were received. There were no suggestions evaluated, adopted or rejected. Eight suggestions are outstanding.

Talks on the physiological properties and assimilation process of tritium were presented to all PRTR Operations personnel.

A re-orientation on radiation protection practices was presented to Ceramics Research and Development personnel assigned to the 308 Building.

Radiation protection orientations were presented to 40 personnel in the 325 and 329 Buildings.

A training session on the hazards and safe handling of thorium oxide was presented to ten Irradiation Processing Department personnel.

A new training bulletin was developed for Radiation Monitoring personnel. The title is "Practical Radiation Problems - Set #1". Copies were issued to all Supervisors, Specialists and Radiation Monitors. The bulletin contains five problems covering areas which were shown by the recent refresher course final examination to require additional training. Additional sets of the problems will be developed to cover other areas in which training is desirable, but formal classroom work is not justified. The Specialists and Supervisors will supply the necessary assistance and supplementary instruction required in the field.

Another course is being organized for radiation protection training of exempt personnel. This will be essentially identical to the course given last spring. The scheduled starting date is September 16. Personnel who were unable to attend the course last spring are being contacted to determine their interest.

Another short refresher course is being organized for HL Radiation Monitors. This course will consist of only four sessions and will include additional instruction in elementary nuclear physics, instrument theory and use of

instruments in dose rate monitoring. New material will include tritium monitoring, effects of radiation of living tissue, and fundamentals of reactor operation. The scheduled starting date is September 15.

D. SIGNIFICANT REPORTS

HW-809027, "Radiological Status of the Hanford Environs for July, 1964", by R. F. Foster, August 11, 1964.

HW-83284, "A Comparison of Theoretical and Measured Dose Rates of Thorium and Thorium Oxide", by J. M. Morgan and L. G. Faust.

HW-83900, "Radiation Monitoring Monthly Report, August 1964", by A. J. Stevens.

HW-82409, "Hanford Whole Body Counter Activities for 1961-1963", by D. N. Brady.

Whole Body Counter	Number of Examinations			
	747-A WBC	1964	Mobile WBC	1964
Subject				
GE Employees				
Regular	27	353	13	611
Incident Cases	17	102	9	16
Terminations	24	181	43	43
New Hires	10	234	12	12
Special Studies	14	73	0	10
Non-Employees	3	30	2	2
Total	95	973	79	694

Bioassay

Analysis	Current Reporting Limit	Results Above Reporting Limit		Samples Assayed	
		Aug.	1964	Aug.	1964
Plutonium	2.2×10^{-8} µc/sam	61	559	480	4309
Fission Prod.	3.1×10^{-5} µc/sam	0	0	0	0
Strontium	3.1×10^{-5} µc/sam	0	11	0	60
Tritium	5.0 µc/l	184	1637	340	2466
Uranium	0.14 ugm/l	0	0	105	1319
Special Studies		0	0	0	180

Calibrations

Portable Instruments	Number of Units Calibrated	
	August	1964
CP Meter	1085	8743
Juno	256	2154
GM	468	4148
Other	228	1880
Audits	111	847
Total	2,148	17,772
Personnel Meters		
Beta-gamma film	324	6650
Rings	74	569
Other film	136	2294
Total	534	9,513
Miscellaneous Special Services	585	2,324
Total Number of Calibrations	3,267	29,609

External Exposure Above Permissible Limits	Current Month	Year to Date
Whole Body Penetrating	0	3
Whole Body Skin	0	1
Extremity	0	1
Hanford Pocket Dosimeters		
Dosimeters Processed	5,695	39,602
Hanford Beta-gamma Film Badge Dosimeters		
Film Processed	2,146	63,701
Results - 100-300 mrads	78	1,148
Results - 300-500 mrads	29	183
Results - Over 500 mrads	5	69
Lost Results	8	102
Average Dose Per Film Packet - mrad (ow)	12	8
mr (s)	130	47
Hanford Film Badge Dosimeters		
Slow Neutron		
Film Processed	170	4,559
Results - 50-100 mrem	0	25
Results - 100-300 mrem	0	29
Results - Over 300 mrem	0	5
Lost Readings	0	5
Fast Neutron		
Film Processed	1,000	5,025
Results - 50-100 mrem	21	126
Results - 100-300 mrem	66	371
Results - Over 300 mrem	1	6
Lost Results	0	3
Hand Checks		
Checks Taken - alpha	30,602	307,151
beta-gamma	41,371	409,784
Skin Contamination		
Plutonium	12	179
Fission Products	37	373
Uranium	0	10
Tritium	0	0
Thorium	0	0

Environmental Monitoring

Samples	August	1964
Air		
Filters	344	2711
Scrubbers	259	1993
Water		
Raw	31	323
Sanitary	109	721
Process	26	191
Vegetation	92	874
Test Wells	154	1886
Fish	85	954
Food Products	59	433
Beef Thyroids	35	335
Waterfowl	7	116
Measurements		
Control Plots	109	621
Aerial Monitoring	1	11
Ionization Chambers	178	1796

for L. E. Newton Jr
Manager
RADIATION PROTECTION

AR Keene:lp

FINANCE AND ADMINISTRATION

ACCOUNTING

Cost Accounting

The Hanford Laboratories' control budget was adjusted during August as follows:

1. The transfer of the cycle analysis function from Programming to Physics and Instruments.

2. Reduction in sponsored funds from the product departments as follows:

	Reductions	New Allocation
Research & Development		
NRD - Reactor (Zircaloy Tube Dev.)	$ 15 000	$ 799 000
Metallurgy (Fuel Dev.)	34 000	355 000
Multiproduct	--	440 000
IPD - Reactor	--	200 000
Diversification	25 000	175 000
Metallurgy	--	50 000
CPD - Fission Product	15 000	35 000
Waste Management	--	518 000
Separations Development	--	258 000
234-5 Pu	--	100 000
Diversification	55 000	275 000
Total Sponsored 02 R&D	$144 000	$3 205 000
Process Technology		
NRD	$ --	$ 20 000
IPD	--	390 000
CPD - Waste Management Purex	--	70 000
234-5 Pu	--	100 000
Purex	--	80 000
Redox	--	55 000
Fission Products	25 000	15 000
Critical Mass Studies	50 000	--
Total Sponsored 02 Process Technology	$ 75 000	$ 730 000

3. Transfer of the PRTR Critical Facility Operation from Test Reactor and Auxiliaries to Physics and Instruments.

4. Inclusion of contracted shop work in the Technical Shops operating budget as opposed to a direct charge to the work order customer.

Special accounting codes established during the month were:

.5J - Graphite Machining for the California Institute of Technology. $3,365 was authorized to Technical Shops for this service. Material is excess from the K Reactors and material costs will be transferred to RLOO-AEC.

.2M - Pneumatic Compaction of Enriched UO_2 for APED. $13,500 was authorized for this work which is being performed on a full cost recovery basis.

With the transfer of Mail and Duplicating Operation from IPD to Hanford Laboratories, organization codes 712A - Mail, and 712B - Duplicating, have been established.

Organization code 7360 - Critical Facility has been cancelled with the transfer of this operation to Physics and Instruments.

Also, due to the transfer of certain programs from Programming, the following codes were established:

7470 - Fuel Cycle Analysis
7870 - Nuclear Health and Safety

Code 7210 - Nuclear Health and Safety has been cancelled.

General Accounting

Approval letter No. AT-356, UO_2 Compaction Work for General Electric Company, was approved by the AEC on August 12, 1964.

Appendix "B", Article VI was modified to provide a per diem allowance of $14.00 ($7.00 under 12 years of age) retroactive to February 1, 1964.

The following revised OPGs were issued during the month of August:

OPG No.	Title
2.2	Organization Announcement
3.5.2	Tuition Refund Program
9.1	Contracts and Purchase Orders (Work Authorization Manual)

Hanford Laboratories' net material investment at August 1, 1964 totaled $27.5 million as detailed below:

		(In thousands)
SS Material		$26 290
Reactor & Other Special Materials		991
Spare Parts		355
Yttrium		26
Subtotal		27 662
Reserve: Spare Parts	$88	
Yttrium	26	(114)
Net Inventory Investment		$27 548

The cumulative value of nuclear material consumed in research by Hanford Laboratories during FY 1965 (at August 1, 1964) is shown below:

02 Program	$ (23 550)
03 Program	66 568
04 Program	(324 281)
Total	$(281 263)

The credit in the nuclear material consumed in research account is due primarily to return of material to Redox at full value.

The status of Hanford Laboratories' heavy water inventory at August 31, 1964 is as follows:

	Current Month		FY to Date	
	Pounds	Value	Pounds	Value
Beginning Balance	32 519	$441 879	32 762	$447 572
Acquisitions				
Scrap Returns (SROO)				
Consumption -1)				
PRTR: Loss	(923)	(12 764)	(1 166)	(16 123)
Scrap		(7 470)		(9 804)
Ending Balance -2)	31 596	$421 645	31 596	$421 645

(1- Consumption - Scrap reflects amount charged to Cost only.
(2 - Includes 10,539 pounds of heavy water scrap valued at $130,385.

A requisition for 55 drums (27,500 pounds) of heavy water was placed during the month to replace losses and degraded material and to provide adequate heavy water for the PRTR.

Nuclear Materials Operation advised us of the start of Survey 22 of which Part 1 will consist of a verification of HAPO inventories of normal uranium, thorium, and U-233 as of the end of September 1964. A team consisting of RLOO-AEC personnel and a member of Nuclear Materials Operation will witness the physical inventory performed by custodians.

The Semi-Annual Major Machine Tool Summary report of HL machine tool utilization was prepared and submitted to Property Management, C&AO, during the month of August.

A report of findings in connection with quarterly inventory of Other Special Materials in the custody of 122 Hanford Laboratories' material holders was prepared. This was a certification type inventory and revealed only minor variances attributed to rounding variances. An adjustment was made for quantity only.

Laboratory Storage Pool activity is summarized as follows:

	Current Month		FY to Date	
	Quantity	Value	Quantity	Value
Beginning balance	2 177	$1 562 594	2 027	$1 493 571
Items received	52	44 581	229	121 796
Items reclaimed by custodians	(178)	(5 322)	(186)	(9 844)
Equipment transfers	(38)	(38 548)	(57)	(42 218)
Items disposed by PDR	(2)	(4 457)	(2)	(4 457)
Items disposed by excessing	(127)	(27 302)	(127)	(27 302)
Ending balance	1 884	$1 531 546	1 884	$1 531 546 -1)

(1- Includes 188 items valued at $124,315 on loan at August 31, 1964.

Loans & Transfers in Lieu of Purchases	Current Month		FY to Date	
	Quantity	Value	Quantity	Value
Loans	23	$ 16 664	33	$ 21 750
Transfers	38	38 548	57	42 218
Total	61	$ 55 212	90	$ 63 968
Operating Costs (8-2-64)		$ 1 484		$ 1 484

Laboratory Storage Pool material and equipment investment at August 31, 1964 totaled $2.5 million as detailed below:

Equipment	$1 531 546
Reactor & Other Special Materials	270 260
SS Material	154 800
Other Material	534 310
Total	$2 490 916

The following contracts were processed in August:

CA-454	John E. Dorn
CA-457	Textron Electronics, Inc., MB Electronics Division
CA-460	H. A. Laitinen
CA-461	John C. Shyne
CA-464	Maurice J. Sinnott
DDR-190	The Kontro Company
DDR-196	San Fernando Laboratories
DDR-197	General Dynamics Corp., Electro Dynamic Dynapak Division
SA-359	Wyandotte Chemicals Corporation
SA-364	Tokyo Shibaura Electric Company, Ltd.
MRO- 77	Consolidated Electrodynamics Corporation

Additional funds were allocated Hanford Laboratories for equipment and capital work order expenditures as shown below:

	New Allocation	FY Total
Equipment		
02	$ 55 000	$155 000
03	45 000	105 000
04	90 000	180 000
05	25 000	50 000
06	25 000	50 000
08	3 000	8 000
Total	$243 000	$548 000
Capital Work Orders	$ 30 000	$ 60 000

Personnel Accounting

All of the exempt personnel folders prepared for the 823 active exempt Hanford Laboratories' employees were given to E. P. Galbraith. The remaining folders for nonexempt employees are ready for BMI.

E. K. Wilkison retired effective September 1, 1964.

Personnel statistics follow:

Employee Changes	Total	Exempt	Nonexempt
Employees at beginning of month	1 826	823	1 003
Additions and transfers in	51	11	40
Removals and transfers out	36	24	12
Employees on payroll at end of month	1 841	810	1 031

Overtime Payments During Month	August	July
Exempt	$ 5 500	$ 7 362
Nonexempt	30 183	27 575
Total	$ 35 683	$ 34 937

Gross Payroll Paid During Month		
Exempt	$ 819 612	$ 837 437
Nonexempt	592 679	577 464
Total	$1 412 291	$1 414 901

Participation in Employee Benefit Plans at Month End	August		July	
	Number	Percent	Number	Percent
Pension	1 702	99.4	1 672	99.3
Insurance Plan - Personal	391		397	
- Dependent	1 420	99.7	1 398	99.7
U. S. Savings Bonds				
Stock Bonus Plan	153	34.5	150	35.5
Savings Plan	71	3.9	68	3.7
Savings & Security Plan	1 213	86.8	1 221	86.8
Good Neighbor Fund	1 325	71.9	1 310	71.6

Insurance Claims	August		July	
	Number	Amount	Number	Amount
Employee Benefits				
Life Insurance		$ -0-		$ -0-
Weekly Sickness & Accident	8	621	13	1 171
Comprehensive Medical	54	3 481	64	3 876
Dependent Benefits				
Comprehensive Medical	98	9 988	107	11 431
Total	160	$14 090	184	$16 478

TECHNICAL ADMINISTRATION

Requisitions for 10 nonexempt employees were filled; 37 remain to be filled.

Suggestion Plan activity:

Suggestions received	37
Suggestions adopted	14
Suggestions rejected	7
Suggestions in process	108

Visitors Center activity:

August attendance	3 222	
Average attendance per day open	107	
Cumulative attendance since 6-13-62	78 095	
Conducted groups	5	(totaling 102 people)

Plant tour activity:

	Number	Total People
General Public Relations Tours	5	102
Special Tours	0	0

Overall recruiting results for August are as follows:

Offers extended	7 (Ph.D. offers only)
Offers accepted	1
Offers rejected	1
Added to roll	7

Advanced Degree - One Ph.D. applicant visited HAPO for an employment interview. Seven offers were extended; one acceptance and one rejection were received. Nine offers are currently open.

BS/MS (Direct Placement) - No offers were extended. There were no acceptances or rejections received. There are no offers currently open.

BS/MS (Program) - No offers were extended. No offers were accepted and no offers were rejected. There is one offer currently open.

Technical Graduate Program - Four Technical Graduates were placed on permanent assignment. Four new members were added to the roll and two terminated from the roll. Current Program numbers 42.

FACILITIES ENGINEERING

At month end, Facilities Engineering Operation was responsible for 12 active projects having total authorized funds in the amount of $10,596,500. The total estimated cost of these projects is $11,793,000. Expenditures through June 30, 1964 were $4,165,000 (latest AEC cost figures).

The following summarizes project activity in August:

Authorized projects at month end ---------- 12

New projects authorized ---------- 1
- CAH-146, Atmospheric Physics Building

Projects completed ---------- 0

New projects submitted to the AEC in August ---------- 1
- CGH-153, PRCF Irradiated EBWR Fuel Handling Facility

New projects awaiting AEC approval ---------- 3
- CAH-114, Critical Mass Laboratory Addition
- CAH-123, Laboratory Fire Protection System
- CGH-153, PRCF Irradiated EBWR Fuel Handling Facility

Project proposals being prepared ---------- 6
- Biology Utilities Extension - 300 Area
- Geological and Hydrological Wells - FY 1965
- Power Supply - Million Amp Welder
- PRTR Increased Power Level
- Shielded Creep Test Facility - 3707-C Building
- Variable Spectrum Test Reactor

The status of active projects follows:

CAH-100 High Temperature Lattice Test Reactor

The Phase I construction bid package was issued on August 18. An addendum covering minor corrections and revisions is now being prepared. Bids are to be opened September 16, 1964.

The current project estimate of $2,500,000 includes only $150,000 for contingency. The Commission has requested that we review the project and prepare a list of potential scope reduction items in an attempt to increase project contingency to $250,000.

Total design by Vitro is about 82 percent complete versus 86 percent scheduled for August 31, 1964. Design cost estimate has now increased to $350,000. Vitro is continuing with Phase II design.

CAH-114 Critical Mass Laboratory Addition

The project proposal submitted to the Commission on November 4, 1963 is still awaiting action by Washington-AEC.

CAH-116 PRTR Decontamination and D_2O Cleanup

Detailed design is approximately 95 percent complete. It was scheduled to be complete on June 15, 1964. Facilities Engineering has held several meetings with AEC and Vitro to discuss detail design comments. Many of our earlier comments had not been resolved prior to the AEC's issuance of drawings to General Electric Company for approval. Resolution was reached on our early comments and changes are now being made. All comment drawings have been received and our comments returned to the AEC. Receipt of all drawings for approval is expected soon.

AEC has prepared the project proposal revision requesting construction funds for the D_2O cleanup portion only.

CAH-119 PRTR Storage Basin and Experimental Facilities Modifications

Detailed design on building and basin addition is about 92 percent complete. It was scheduled to be complete on June 15, 1964.

Work is progressing by GE on procurement specifications for the underwater equipment.

Construction work was started by J. A. Jones forces during the week of August 3, 1964. Work is progressing on relocation of manhole No. 4, footings for extension of the load-out crane, and on new fuel storage supports.

CAH-123 Laboratory Fire Protection System

No action was taken by the Commission during the month.

CAH-126 Waste Transport System

Design is in progress on loading and unloading facilities. Vitro Engineering Company has just started on their study to prevent freezing of wastes.

CAH-136 Service Addition - 327 Building

Detailed design started on August 10, 1964 after approval of Title I design.

CAH-137 Temporary Physical Sciences Center

Vitro Engineering Company has completed design for the computer room floor. J. A. Jones is preparing to purchase the floor on a furnish and install basis.

Comments have been returned to Vitro on power and fire protection.

CAH-146 Atmospheric Physics Building

AEC is conducting negotiations with an off-site architect-engineer for award of a design contract on this facility.

CAH-151 Office Addition - 308 Building

An inspection was made of the building ventilation control equipment with Vitro Engineering Company personnel to clarify questions on the addition. Preliminary architectural drawings were received from Vitro for comment. Work is progressing on electrical and mechanical design.

CGH-153 Plutonium Recycle Critical Facility - Irradiated EBWR Fuel Handling

A project proposal requesting total project funds in the amount of $40,000 was submitted to the AEC on August 17, 1964.

CAH-916 Fuels Recycle Pilot Plant

Construction is 73 percent complete compared to a scheduled 60 percent. Placement of normal and high density concrete is continuing on the Hot Pilot and Metallurgical Cell walls. Interior concrete block walls are being laid. Window wall liners, sleeves, and filter frames were installed in the Hot Metallurgy Cells and the cell metal liner sections are being welded together. Installation of second and third floor piping and electrical work is continuing. The inside of the exhaust stack and the waste vaults have been painted with protective coatings.

CAH-962 Low Level Radiochemistry Building

Construction is 18 percent complete versus a scheduled 17 percent. The foundation walls have been completely poured and 80 percent of the first floor. The exterior wall has been waterproofed. Preparatory working slabs have been poured for precasting wall panels. Piping is being run in the basement and through the first floor slabs. Electrical work is continuing. Erection of structural steel has been started.

CAH-977 Facilities for Radioactive Inhalation Studies

A rough draft revised project proposal for construction of this facility at the 300 Area Biology Laboratory site instead of 100-F Area is being prepared at AEC's request.

CAH-982 Addition to the Radionuclide Facilities

A rough draft revised project proposal for construction of this facility at the 300 Area Biology Laboratory site instead of 100-F Area, as originally planned, is being prepared at AEC's request.

Utility Project and Relocated Biology Facilities in the 300 Area

A meeting was held August 18, 1964 with AEC, Biology, and Facilities Engineering to consider the new site in the 300 Area for the Biology facilities.

Comparative costs for providing permanent services at this time for future buildings versus installing some temporary services were considered. AEC has requested additional cost figures for comparison. These are currently being prepared. A project proposal will be prepared after the type and size of utility is resolved.

Engineering Services and Plant Engineering

Engineering work was performed in support of design and construction on active projects, project proposals, preliminary planning, and design criteria for new projects. Principal work items included: (1) field consultation and review of vendor drawings for projects CAH-916, Fuels Recycle Pilot Plant and CAH-962, Low Level Radiochemistry Building; (2) preparing functional specifications for procurement of underwater equipment and reviewing ventilation flow diagram on project CAH-119, PRTR Storage Basin and Experimental Facilities Modifications; (3) reviewed the simulator vessel proposal and reviewed the drawings for the dry and wet wells on the containment vessel for the Containment Systems Experiment; (4) work is continuing on the preparation of a design criteria document for a PRTR replacement deaerator; and (5) the design criteria for a shielded creep test facility at 3707-C building is being revised.

Facility planning and budget study work included: (1) preparation of construction data sheets for three separate proposals for the Poodle Thruster facilities; and (2) the adequacy of the supply of well water to the 324 building.

Engineering and consulting work was provided to research and development personnel as requested. Major work items included: (1) assistance was provided in determining electrical components to be used in conjunction with the waste calcination work in the 324 building; (2) shielding modifications are being made for the experimental spectrometer in the 105-KE building; and (3) drawings are now being prepared showing the scope and lattice spacing for the third core of the PRCF light water facility.

Plant engineering work during the month included: (1) improving the 328 building office ventilation system; (2) the existing drain piping in the northwest section of the second floor of the 308 building was revised; (3) a new refrigerated air conditioning system serving the metallography laboratories of the 306 building was completed; (4) bids were reviewed for a proposed auxiliary compressor for the 340 building; (5) the Ceramics Shop exhaust system in the 325 building basement was reviewed; (6) an electrical power usage forecast was prepared and submitted to the Utilities Operation for predicted HL loads in 1965; and (7) necessary changes were outlined to the 108-F addition ventilation control valves to permit 40 pound steam usage.

Consulting service for other departments included assistance on: DC power supply requirements and specifications for a proposed arc-type metal deposition process.

Pressure Systems

The Containment Systems Experiment field work and costs are on schedule and within the estimated amount. Chicago Bridge and Iron contract for the containment vessel has been extended from January 10, 1965 to February 17, 1965, a total of 38 days' time extension. This is due to a three-day time required for change orders and 35 days' time allowance because of steel delivery. Shop drawings were received and are presently being reviewed for compliance with our requirements. Struthers-Wells Corporation has submitted their proposal for construction of the simulator vessel. A technical review of the proposal has been made. Further negotiations will be conducted by J. A. Jones Company towards clarification of technical questions and to arrive at a cost price. Design effort for systems associated with the vessels is being conducted by Vitro. A preliminary drawing list and schedule were submitted. A review of this list has been made and comments returned to Vitro.

Purchase information for a High Pressure Furnace, which will be a code vessel, is 60 percent complete.

The third-party inspector reviewed the records for the High Temperature Gas Loop. He also inspected seven elevators in HL buildings.

Facilities Operation

Costs for the month of July were $138,798, which is 68 percent of the forecast for the month. During this month improvement and building maintenance costs were lower than forecasted. The return to normal maintenance work schedule has been affected by vacations and preparation for priority improvements.

The emergency lighting (exide lights) program is 100 percent complete. Emergency lights have been installed in 327, 328, 325, and 3760 buildings.

Interior painting in 325 building is progressing slowly; however, this building will be completed before moving to the next building on the paint list.

The 3707-B building was transferred to HL from IPD for janitor services.

Classified island operation of 329 building is being held up awaiting clarification of AEC security policies relative to laboratories containing classified materials.

On August 3, 1964, 21 janitors and one foreman were transferred from IPD to the Facilities Operation, and on August 17, 1964 six janitors were transferred from HL Maintenance.

The following table summarizes the Waste Disposal Operation:

Item	June	July
Concrete waste barrels disposed to 300-wye burial ground	10	0
Concrete waste barrels disposed to 200-W burial ground	9	9
Loadluggers of dry waste disposed to 300-wye burial ground from 300 Area sites other than the 325 building	21	33

Item	June	July
Loadluggers of dry waste disposed to 300-wye burial ground from the 325 building	4	7
Loadluggers of dry waste disposed to 200-W burial ground from 300 Area sites	7	7
Containers of high level dry waste disposed to 300-wye burial ground vertical pipes	89	96
Crib waste volume, gallons	270 000	300 000

No unusual incidents occurred this month.

The volume of dry waste disposed to the burial ground has risen again.

Markers are being installed at 300-north burial ground to put it in terminal condition.

Two large dry waste disposal tanks have been installed at 300-wye burial ground and will be put into service in the near future.

None of the retention basins exceeded Class II activity levels during the month.

Completion of the retention waste monitoring systems is being delayed because of deficiencies in some of the electronic components. Purchasing is contacting the vendor.

Building Operations

In the 3760 building the No. 9 booster coil has been repaired and reinstalled to improve conditions until a new coil arrives. Reheat coils in the 326 building were repaired.

Ventilation noise problems in the 329 building were corrected. The air balance group balanced flows on the new air conditioner in the 306 building and rebalanced air flow on the first floor of the 108-F building.

Outages are scheduled in the 325 and 3760 buildings for Saturday, August 29, to perform maintenance work on the service water line and supply fans, respectively.

Drafting

The equivalent of 100 drawings were produced during the month for an average of 38 man-hours per drawing.

Major designs completed or in progress are: (1) a powder processing glove box line; (2) diagrams of all air service lines in the 309 building; (3) a high temperature furnace for the NASA program; (4) FRPP service piping to waste calcination equipment; (5) underwater measuring equipment for calibrating elements in N-Area; (6) electrical work for waste calcination equipment in FRPP; (7) mock-up of equipment in FRPP Pyrochemical cell; (8) scope work for equipment layout for PRTR increased power level; (9) a sodium pump test facility; (10) a critical mass expansion tank for building 209-E; and (11) a scope design for the polonium hood complex.

Drafting service was also supplied in support of other laboratory engineering programs.

Construction

	Unexpended Balance
Orders outstanding beginning of month	$476 768
Issued during the month (incl. suppl. & adj.)	397 025
J. A. Jones expenditures during month (includes C.O. cost)	149 278
Balance at month end	724 515
Orders closed during month	168 635

Maintenance Work Orders active - 4; Face Value - $16,789.

Major nonproject jobs in progress during the month were: (1) review of preliminary cost estimate for a contract on the crib waste leak detection program; (2) in the 100 areas, the third floor partitions are completed in the 108-F building, the south section (69 pens) of the dog pens have been completed at the 144-F building, an intercom system is being installed in this building, the electrical services have been revised in the 146-FR building, the dark room in the 1706-KEL building is being modified, and modifications to the stairway and electrical service in the 189-D building are being made; (3) in the 200 areas, the work on the 221-T building to modify it for the Containment Systems Experiment is nearing completion except for canyon lighting installation; (4) in the 300 area, procurement and installation is in progress for a new rectifier for the arc-melt furnace, the hydraulic snubbers for the 309 building are 70 percent installed, also a manhole has been installed for this building and a contract awarded

to repair and recoat the exterior of the containment vessel; in the 314 building the autoclave pit and storage area is completed as is the structural housing for EDEL II loop; in the 321 building electrical circuits and a foundation have been installed for a computer, and two offices are being constructed; in the 3718-C building the excavation is completed for the foundation of an addition to the warehouse, 80 percent of the flow meters and 60 percent of the radiation meters are installed in the retention lines; and (5) bids have been issued for the computer floor of the 3201 building.

Well Drilling Program

A design criteria for the FY 1965 well drilling program is currently being approved within Laboratories.

Waste Solidification Engineering Prototype

Delivery of rack No. 3-B was made on schedule on August 19, 1964. Other work was on schedule until the pipefitters went out on strike.

GENERAL

There were no reports of inventions or discovery during the month.

Acting Manager
Finance and Administration

DS Parsley:RDT:whm

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Plutonium Recycle Test Reactor

Operation

Reactor output for August was 580 MWD for an experimental time efficiency of 47% and a plant efficiency of 27%. There were eight operating periods during the month, three of which were terminated manually and five were terminated by scrams. A summary of the fuel irradiation program as of August 31, 1964, follows:

	Al-Pu		UO_2		PuO_2-UO_2		Other		Program Totals	
	No.	MWD	No.	MWD	No.	MWD	No.	MWD	No.	MWD
In-Core	0		8	1850.5	77	11945.9			85	13796.4
Maximum				322.4		336.7				
Average				231.3		155.1				
In Basin	7	572.5	25	2564.1	47	5334.5			79	8471.1
Buried							1	7.3	1	7.3
Chem. Process.	68	5465.8	35	1965.8					103	7431.6
Program Totals	75	6038.3	68	6380.4	124	17280.4	1	7.3	268	29706.4

Note: (MWD/Element) x 20 $\simeq$ MWD/TU for UO_2 and PuO_2-UO_2.

Heavy water loss and indicated helium loss for the month were 923 pounds and 149,129 scf., respectively.

Equipment Experience

A total of 184 reactor outage hours was charged to repair work. Main items were:

Vibration check and repair of primary pumps
Jumper repair
Helium compressor repair
Tube-to-nozzle regasketing
Rupture Loop repairs

Preventive maintenance required 385 manhours, or 8.8% of the total maintenance effort.

An order was placed for 20 replacement PRTR process tubes, with delivery expected during the first quarter of 1965. Cost of the order is ~ $95,000.

Improvement Work Status (Significant Items)

Work Completed

Installation of New Alarm Annunciator
Gas Moisture Detection System Blower Exchange

Work Partially Completed

Corrosion Loop Installation
Primary Water Sample Station
Shim Rod Shroud to Top Cap Modification
Repair and Recoating of PRTR Containment Vessel Roofing
Air Lock Door Operators
Modification to PRTR Warehouse 3718-C
Vibration Snubbers for Earthquake Protection
Supplemental Emergency Water Addition
Voltage Off-Normal Detection and Alarm for 24-Volt Battery System
PRTR Steam Utilization
Additional Fuel Storage and Examination Facility

Design Work Completed

Mark III Shim
Installation of Second Generation Shim Rod
Creep Test Facility

Design Work Partially Completed

Decontamination Building and D_2O Cleanup Facility
Flux Wire Scanning System
Thermal Barrier Seal and Hoist Improvements
Pneumatic Irradiation Facility
PRTR Experimental and Building Facility Addition
PRTR Increased Power Level

Process Engineering and Reactor Physics

PRTR Test 94, Corrosion Study in Calandria Atmosphere, has been completed. The test coupons have been discharged and returned to the test sponsor for study.

Calculations designed to define the characteristics of the high power density core are continuing. Radial and axial flux distributions have been calculated and expected xenon transient magnitudes have been computed. Coolant voiding studies and moderator level coefficient studies are in progress.

PRTR Test 93, Hydrogen Addition to Bulk Helium, was completed, recommending continued addition of 1% H_2 to the bulk helium supply.

Gas gap measurements between the process tubes and the shroud tubes were made for 10 process channels. Tube 1748, which indicated less than 020" clearance, was relocated in process channel 1253 and a new tube placed in channel 1748. Gas gap measurement between the new tube and shroud indicated ~.050". Process tube 6084 from channel 1253 was removed for mechanical and metallurgical testing. The interior of the shroud tube of channel 1748 was visually examined. No defects were observed.

Experimental Reactor Services

The status of the various test elements at the end of August 1964, is shown below. Those elements which had reached their assigned goal exposure or had been permanently discharged for other reasons prior to August 1, 1964, have been deleted from this table.

Test No.	Channel Location	Element Number	Description	Date Initial Charge	Date Discharged	Approximate Accumulated MWD
14	1956	5097	Moxtyl-Swaged	4/2/62	--	205.6
14	1352	5098	Moxtyl-Vipac	5/8/62	--	309.1
14	1758	5099	Moxtyl-Vipac	5/8/62	--	216.9
48	1156	5150	Moxtyl ($\frac{1}{2}$" x $\frac{1}{2}$" pads)	8/1/62	--	213.8
54	1542	5116	Moxtyl (clip on pads)	5/8/62	--	225.6
54	1554	5118	Moxtyl (clip on pads)	5/8/62	--	336.7
61	1249	5185	Moxtyl-Physics	5/28/63	--	219.3
61	1354	5186	Moxtyl-Physics	5/28/63	--	212.9
61	1445	5192	Moxtyl-Physics	6/13/63	--	217.2
67	1047	5117	Moxtyl (Repaired Wire)	10/20/63	--	179.4
80	1746	5214	Moxtyl (1% PuO_2, Swaged)	11/18/63	--	166.3
85	1855	5230	Moxtyl (1% PuO_2, Vipac)	1/30/64	--	107.7
37	1548	1098	UO_2-Physics	5/12/62	--	202.8
37	1550	1097	UO_2-Physics	5/12/62	--	217.3
37	1552	1099	UO_2-Physics	5/12/62	--	186.1

Fuel Element 5118 was rebanded in the basin after having 5 bands damaged during the transfer operation. One band was given to Chemical Metallurgy for corrosion evaluation.

Three new fuel elements and 21 irradiated fuel elements were inspected in July.

Fuel Element 1502 was shipped to Radiometallurgy for examination and testing together with rods and other components from eight fuel elements.

Fuel Element Rupture Testing Facility

Difficulty was encountered during the previous operating run with both the test section outlet pressure and temperature control. The pressure control difficulties were traced to the fatigue failure of the positioner pilot valve on RL-3. A vibration resistant pilot was procured and installed. Temperature control has been a problem since loop activation, but has generally been tolerable until the previous operating run. The problem is due to oversized valve trim in temperature control valve RL-2 and excessive time lags in the process. New, smaller sized trim has been ordered for the valve and PRTR Test 103 was issued in an attempt to reduce process lags.

FERTF Test 7, Irradiation of a Longitudinal Slit Defected UO_2, was begun with the reactor startup of 8-7-64. A standard size UO_2 PRTR fuel element, #1039, was intentionally defected with a saw cut estimated to be about 1.5 inches in length. During August, the test element was subjected to seven critical periods which included two manual reactor shutdowns from 5 and 15 MW respectively, one scram from 28 MW, and four scrams from 70 MW. Following these power cycles, the fuel element was visually examined in the storage basin. There was no apparent evidence of defect propagation or of a significant release of fuel material.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 19,015 hours. This includes 12,726 hours performed in the Technical Shops, 4,529 hours assigned to J. A. Jones Company, and 1,760 hours assigned to off-site vendors. Total shop backlog is 19,864 hours, of which 90% is required in the current month with the remaining hours distributed over a three-month period. Overtime worked during the month totaled 1,013 hours or 5.7% of the total available hours.

Distribution of time was as follows:

	Man Hours	% of Total
N Reactor Department	1 911	10.0
Irradiation Processing Department	3 122	16.5
Chemical Processing Department	159	.8
Hanford Laboratories	13 823	72.7

LABORATORY MAINTENANCE OPERATION

Total productive time was 17,500 hours of 20,600 potentially available. Of the total productive time, 93% was expended in support of Hanford Laboratories components, with the remaining 7% directed toward providing service for other HAPO organizations. Craft overtime worked during August was 3.4% of total available hours.

Manpower utilization (in hours) for August was as follows:

A.	Shop Work		1 700
B.	Maintenance		7 200
	1. Preventive Maintenance	2 200	
	2. Emergency or Unscheduled Maintenance	2 000	
	3. Normal Scheduled Maintenance	3 000	
C.	R&D Assistance		8 600

WD Richmond

Manager
Test Reactor and Auxiliaries

WD Richmond:JGZ:bk

INVENTIONS OR DISCOVERIES

All persons engaged in work that might reasonably be expected to result in inventions or discoveries advise that, to the best of their knowledge and belief, no inventions or discoveries were made in the course of their work during the period covered by this report except as listed below. Such persons further advise that, for the period therein covered by this report, notebook records, if any, kept in the course of their work have been examined for possible inventions or discoveries.

INVENTOR	TITLE OF INVENTION OR DISCOVERY
R. D. Nelson	Production of Crack-Free High-Purity Plutonium (HW-83733)
R. D. Nelson	Strengthening of the Beta Phase in Unalloyed Plutonium (HW-83754)
C. A. Rohrmann	A Process for the Manufacture of Objects of Vitreous Silica (HWIR-1748)

R S Paul

Acting Manager, Hanford Laboratories

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