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HANFORD LABORATORIES MONTHLY ACTIVITIES REPORT

JUNE 1964

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HANFORD LABORATORIES
MONTHLY ACTIVITIES REPORT
JUNE 1964

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By H. Magafna
Date 6-19-91

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Section Managers

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Date 5-[illegible]-73

July 15, 1964

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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PRELIMINARY REPORT

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Table I - Hanford Laboratories Force Report

Date: June 30, 1964

	At Beginning of Month		At Close of Month		
	Exempt	Salaried	Exempt	Salaried	Total
Chemical Laboratory	152	124	158	125	283
Reactor & Fuels Laboratory	211	196	215	200	415
Physics & Instruments Laboratory	116	77	128	78	206
Biology Laboratory	44	63	46	67	113
Applied Mathematics Operation	20	6	21	6	27
Radiation Protection Operation	44	90	43	87	130
Finance & Administration Operation	129	116	131	119	250
Programming Operation	22	5	23	5	28
Test Reactor & Auxiliaries Operation	63	309	59	312	371
General	3	5	3	5	8
TOTAL	804	991	827	1004	1831

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BUDGET AND COST SUMMARY

June operating costs totaled $3,319,000, or an increase of $758,000 from the previous month. Fiscal year-to-date costs are $32,794,000, or 98% of the $33,420,000 control budget.

Hanford Laboratories' research and development costs for June compared to last month and the control budget are shown below:

(Dollars in thousands)	COST Current Month	Previous Month	To Date	Budget	Percent Spent
HL Programs					
02	$ 175	$ 105	$1 137	$1 160	98
03	4	-0-	253	250	101
04	1 346	1 006	14 017	14 045	100
05	141	111	1 417	1 438	99
06	341	275	3 324	3 352	99
07	15	-	15	17	88
08	33	64	284	290	98
	2 055	1 561	20 447	20 552	99
Sponsored by					
NRD	147	116	1 801	1 798	100
IPD	38	31	489	497	98
CPD	206	160	1 778	1 819	98
	$2 446	$1 868	$24 515	$24 666	99

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RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

Thirteen N-Reactor coproducer fuel elements have been irradiated to an average exposure of 1300 Mwd/ton. There was no evidence of swelling in the target component, nor was there evidence of bonding between the Zircaloy-4 can and the aluminum target.

The first coproducer production test irradiated in the N-Reactor proper will involve nearly 800 elements. Hanford Laboratories began target fabrication in June. To date, the target elements fabrication is over one-third complete with completion scheduled for August 1.

A thorium fueled fouling probe designed and fabricated in Hanford Laboratories has been examined after receiving 1000 Mwd/ton exposure. No deficiency in performance was observed. A second detector is operating satisfactorily in a KER loop.

Preparation of end caps for the hot-headed projection welding end closure has been improved in cost and quality using electron beam evaporation to place the braze layer on the end cap.

Crud deposition on zirconium-clad fuel elements exposed in the stainless steel Hanford KER loops to high-temperature pH 10 ammoniated water was duller and darker in appearance than that which had been encountered in a carbon steel loop with ammonia it was also much heavier than had been encountered in these stainless loops using LiOH.

Tests were conducted to determine whether residual pickling acid during fabrication could have caused the observed intergranular attack on the N-Reactor steam generator tubing. Drops of acid were placed on samples that were then subjected to the same conditions as in the manufacture of the steam generators. Intergranular attack was produced.

Analyses were continued of laboratory experiments; an electrically heated, full scale model of the downstream half of an N-Reactor fuel column was used. Equations were developed to allow extrapolation of the pressure-drop flow data to pressures other than those used for the experiments.

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Aqueous ammonium hydroxide solutions were irradiated in the single pass facility to study the formation of hydrazine from ammonia in aqueous solutions. The conversion ratio (moles of N_2H_4 formed per mole of NH_3 decomposed to N_2 and H_2) increased from 5×10^{-5} to 5×10^{-4} as the NH_3 concentration was increased from 30 to 800 ppm, but decreased as the holdup time was increased from 22 to 240 minutes.

Three thorium-uranium fuel elements in the ETR have now received 7400 Mwd/ton exposure and show 0.8 vol% swelling. These elements have operated at a heat flux of 850 to 1 million Btu/(hr)(ft^2) and show a theoretical minimum volume expansion.

An aqueous solution of 0.75M NH_4OH, 0.5M N_2H_4, and 0.25M EDTA $(Na)_4$ was found to be a promising possible reagent for single step decontamination of stainless steel. Decontamination factors up to 14 on PRTR jumper samples were obtained in beaker tests.

Examination of a discharged PRTR Zircaloy-2 pressure tube, exposed 200 days at water temperatures in excess of 400 F (233 C), showed twice the corrosion product weight-gain in the flux zone of 4×10^{12} to 2×10^{13} nv (> 1 mev) as in unirradiated sections of the same tube.

Pit depth measurements on the PRTR deaerator have been repeated. The pits are deepening at the rate of 40 mils/yr; the deepest observed was 160 mils.

The first irradiation of a long, water tube element was successfully inaugurated in PRTR. A new mode of Zircaloy cladding penetration was identified in a failed PRTR element.

Six PRTR fuel elements were fabricated.

Forty-eight kilograms of mixed oxide were densified by the Nupac process for PRTR and 42 kilograms for the PRCF program.

Irradiations of prototypic EBWR fuel rod segments continue to reveal anticipated satisfactory performance at heat ratings well in excess of that proposed for EBWR.

[redacted]

Chemical analysis confirmed the uniform distribution of plutonium, originally introduced as a coaxial alloy wire, throughout the initially molten regions of a UO_2 fuel element.

A brief study was made to compare the economics of boiling H_2O coolant with liquid or boiling D_2O coolants in D_2O moderated reactors. It was tentatively concluded that H_2O cooling had a net advantage of 0.5 to 0.6 mil/kwhr over D_2O cooling.

Laboratory experiments indicated that existing theories for critical flow of steam-water mixtures discharging from pipes would not apply to elbows.

It was found that pressure fluctuations caused a change in the location and magnitude of boiling burnout heat fluxes for flow through a 0.444 in. electrically heated tube.

PuB_2 is the only stable plutonium boride found below 900 C.

Beta-Pu_2O_3 can be prepared by reacting plutonium hydride with thermally reduced PuO_2. The beta-Pu_2O_3 has a greater oxidation resistance than PuO_{2-x}.

Application of an image intensification system to x- and gamma-ray radiography provided resolution and sensitivity, with dynamic response, that appeared to exceed that available using conventional time exposure radiographic techniques.

Clad cermet discs containing beta-Pu_2O_3-50 vol% W, PuN-50 vol% W, and PuO_2-62 wt% (80 Ni/20Cr) were prepared by impaction.

Un-20 wt% PuN pellets and PuN-Pu and PuN-W cermet specimens were discharged from the MTR.

Homogeneous distribution of plutonium, equivalent to that in $(U, Pu)O_2$ made by coprecipitation, was demonstrated in impacted, dry ball milled mixtures of UO_2 and PuO_2.

UN irradiated at rod powers sufficient to cause melting in UO_2 did not reach sintering temperature, thus demonstrating its greater thermal conductivity.

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UO_2 pellets melted by direct induction heating in a dried argon 8% H_2 atmosphere remained nearly stoichiometric.

Radiochemical analyses showed that cesium and silicon concentrate in uranium inclusions formed in UO_2 irradiated at high temperatures.

Melting points of Sm_2O_3 and Nd_2O_3 are 2250 C and 2260 C, respectively.

BeO-nickel coated PuO_2 mixtures were densified by impaction.

The high temperature dilatometer was calibrated to 1600 C, and data were obtained on an uranium dioxide single crystal specimen.

Electrical resistivity data were obtained for UO_2 at approximately the melting point.

Uniform, adherent deposits of vapor plated tungsten were made on W-UO_2 cermets by transfer of the tungsten from molybdenum substrates during pneumatic impaction.

Elimination of a second phase present in a batch of UO_2 for the EBWR loading appears to correct difficulties experienced in pneumatically impacting the material to 99% TD.

Three hundred and twenty additional EBWR fuel rods were fabricated for physics tests.

Sixty to seventy percent recovery of internally damaged EBWR fuel rod cladding tubes was achieved by internal honing. Sample tubes were exchanged with ANL to further compare nondestructive test procedures.

The Hanford developed exposure unit for comparing fast neutron irradiation effects caused by neutron fluxes of varying spectra was tested successfully with ductility data from two different reactor sources.

Oxidation data for small samples of graphite in helium containing water vapor were successfully used to calculate the oxidation rates of samples having larger diameters.

Platinum was successfully demonstrated as a standard for thermal diffusivity measurements over the range 25 to 500 C.

[redacted]

The 2C-2 capsule containing boronated graphite samples continues to operate satisfactorily. Irradiation tests run at low temperature indicated increasing tendency for expansion with decreasing temperature of the exposure.

Two uranium specimens that were irradiated at 525 and 575 C (977 and 1067 F), respectively, were pulse-heated into the beta phase. No density change occurred, but preliminary metallographic examination indicated that much of the crystallographically aligned porosity which existed in the as-irradiated condition has moved to original alpha boundaries.

Solution and precipitation hardenable nickel base alloys have been irradiated to an exposure of 5×10^{19} nvt at 280, 580, and 740 C (536, 1076, and 1364 F); in addition, the mechanical properties of the alloys have been tested at room temperature.

A formal report, "Second-Phase Particles in Dilute Uranium Alloys - Quantitative Metallography," HW-80349, was presented at the June 22-24, 1964, Eighteenth Meeting of the AEC Metallography Group.

Corrosion of molybdenum and TZM molybdenum alloy in 1000 C (1832 F) oxygen is highly pressure sensitive in the range 5×10^{-4} to 5×10^{-3} mm mercury.

Additions to the work force for the model gas loop accelerated construction significantly. As of June 18, 1964, construction of the model high temperature gas loop was 80% complete. By the end of June, the gas-bearing compressor will be used to circulate air, at standard temperature and pressure, in the loop for the initial phase of loop startup.

An absorption column for the gas chromatograph packed with Linde 13X molecular sieve has produced absorption peaks of improved sharpness.

Preirradiation characterization of annealed rhenium foils has been completed, and four capsules with a total of 24 samples have been prepared for irradiation.

A formal technical report, "Quench-Hardening in Polycrystalline Nickel," HW-82708, has been prepared for publication.

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The beta-to-alpha transformation kinetics of 0.005-in. -thick wafers of electro-refined plutonium were investigated at -196 C (-320.8 F). The transformation was complete after 5 sec. The physical damage in the form of internal voids was small.

The steady state creep rate of the beta phase of plutonium was found to depend upon the previous transformation, i.e., the creep rate of the beta phase formed by transformation from alpha was at least two orders of magnitude greater than that formed by transformation from the gamma phase. On the other hand, the steady-state creep rate of the gamma phase was independent of transformations.

Investigation of the fiber texture in alpha plutonium resulting from transformation under pressure has continued. The observed sensitivity of the (020)-(211) doublet to sample orientation has been shown to result from $(\bar{2}03)$ planes consistently aligned parallel to the fiber axis.

Exploratory experiments with a 600 kva resistance welder indicate that welding of graphite with this machine may be possible.

A fuel element design consisting of mechanically interlocked W-UO_2 fuel plates forming a continuous "egg crate" is under study for Lewis Research Center. Another design being developed uses three tungsten rods to align the cermet grid sections that are supported on the alignment rod seats. Simulated fuel grids and related parts are being fabricated for assembly and mechanical stability studies.

W-UO_2 cermet specimens for thermal cycling studies have been prepared using specially purified components and additional heat treatment after compaction.

Two time-lapse movies have been taken of a small slice (0.2 x 1 x 8 mm) of a Rover fuel element during heating in the reflection stage of the electron microscope.

Densities of 96.1 to 98.5% TD were obtained in a study of the effect of pressure and temperature on the density of tungsten and W-UO_2 cermet fabricated by pneumatic impaction.

[redacted]

Various W-UO_2 and tungsten fuel assembly components were fabricated and sent to Lewis Research Center.

Impact bonding by pneumatic impaction followed by hydrogen sintering produced a metallurgical bond in the W-to-W-UO_2 joints of a 1/8 in. square honeycomb grid fabricated from NASA rolled plate.

2. Physics and Instruments

Analog simulation studies of N-Reactor were completed for 50% and 70% power level conditions. An additional study was made at 125% power level to determine the effectiveness of the large 25,000 gal surge tank.

The sensitivity of a Pu^{239} liquid counting system has been improved to counting rates of 3×10^4 counts/min per 1 g/liter of solution. Tests were made on 2 g/liter and 10^{-3} g/liter samples using NaI(Tl) detectors to monitor the Pu^{239} 17 kev X-rays.

Nondestructive inspection of 94 irradiated N-Reactor fuel elements revealed internal core cracks in three inner and one outer fuel tubes. Question exists as to whether the outer fuel defects were caused by the suspect element being accidentally dropped before inspection. The inner tubes were not dropped.

Emergency assistance was provided N-Reactor Department on a weekend round-the-clock effort to radiographically inspect high pressure valve castings. Several flaws were detected, repaired, reradiographed, and evaluated.

Fuels Engineering for N-Reactor has performed evaluation tests on the cap-to-core bonding test for chevron end closures and demonstrated good correlation between the test and unbonds. The test has been incorporated into existing equipment in the 333 production building and is operating on a routine basis.

A production test designed to determine the capability of NT-2 X-Ray Fluorescence Test has been completed. Results demonstrated the test has the sensitivity and stability to inspect production at the

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required sensitivity and throughput. The production capacity of one unit is estimated at 15 inner fuels per hr, or 8 outer fuels per hr.

Work on the determination of N-Reactor lattice physics parameters and neutron spectral characteristics is continuing. Irradiated detector pin data are being analyzed to determine p, ϵ, C_o, r, and neutron temperature.

Fuel cycle analyses for Phase III(power only) operation of N-Reactor have been initiated.

A series of critical mass experiments was completed with plutonium nitrate solutions in a reflected 11.5 in. diameter sphere, and a new series was begun with a 15.2 in. sphere. At the Critical Mass Laboratory, a fully unreflected plutonium solution assembly was made critical for the first time with the larger sphere.

A new higher intensity pulsed neutron generator was received for use in continued development of promising methods for making subcritical reactivity measurements on in-plant arrays of fissionable material.

Four physics papers were presented at the national meeting of the American Nuclear Society: two on critical mass studies, one on relationships between physics uncertaintites and plutonium fuel cycle economics, and one on compact water-moderated plutonium burners.

Measurements were completed to remove systematic errors from previous data on the scattering law for neutrons from 95 C H_2O.

Measurements of the neutron flux from the beam hole to be used for time-of-flight neutron spectroscopy gave intensities in good agreement with expected values.

Data processing was completed on previous measurements of the Mev neutron total cross sections of oxygen, nitrogen, and deuterium.

Several modifications to one of the heavy-element mass spectrometers were completed including the installation of an improved magnet sweep coil.

EBWR fuel experiments for lattice spacings of 0.93, 0.90, and 0.60 in. have been completed in the Critical Approach Facility. Substitution [redacted]

and worth measurements with EBWR fuel in the H_2O moderated PRCF are continuing.

Design calculations on the "reduced core PRTR" are in progress. Appropriate physics models for these calculations have been adopted.

In HTLTR design, a major concern is the corrosion of reactor components by contaminant gases arising from incomplete purging of the graphite and insulating brick. Tests have been started in which the amount of gas effluent will be measured during repeated heatings of the test samples.

Planning of the PCTR Phoenix experiments is progressing well and experiments will begin soon. Exploratory studies on Phoenix cores have now been extended to include ZrH as a moderating material.

The burnup code ZODIAC is being streamlined and a new version ZODIAC-2 has been released for use under programer supervision.

One-quarter in. diameter eddy current test coils applied to the internal surface of N-Reactor process tube samples have detected 500 ppm hydride concentration.

Surface fatigue was detected in three metal samples by ultrasonic critical angle tests. Preliminary results appear to show promise of detecting metal structure changes before crack initiation. Fatigue areas in the prepared stainless steel samples were also detected by specially developed eddy current tests.

Preliminary studies of wavefront reconstruction methods of imaging ultrasound are giving promising results. Two pulsed ultrasonic beams oriented to interfere at a water surface have produced four observable orders of diffraction on either side of the undiffracted zero-order image.

The AEC/AECL program on nondestructive testing of fuel sheath tubing has been completed with shipment of the ultrasonic tube testing equipment to the Geneva Conference. Program terminal reports are essentially complete.

An analog study of the PCTR hazards was completed. Variations of reactivity were introduced into the reactor simulation. The resulting power

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excursions were terminated by dropping the control rods and by melting of the fuel elements.

Efforts to obtain experimental regenerating neutron flux detectors moved forward with acquisition of sample quantities of U^{234}. The material was enriched on-site to 10.2% U^{235} and transmitted to GE-APED for use in fabricating two experimental units. The completed detectors are expected mid-August.

Microwave neutron flux monitor experiments designed to test the cross-coupling characteristics of an ionized plasma were prematurely terminated before useful data were obtained because of water leakage of the detector assembly.

Meteorological factors relating to retention of land on the Wahluke Slope were summarized for presentation to the Advisory Committee on Reactor Safeguards at the request of the AEC. Presentation was made at AEC Headquarters on June 19.

The gradual accumulation of data from gamma-ray spectroscopy of urine samples is providing unique data on the amounts of Na^{22}, Cs^{134}, and Cs^{137} in Alaskan Eskimos and in Richlanders. The presence of Na^{22} now seems adequately explained by the amounts found in meats; there may be enough in some Eskimos to measure with the whole body counter this summer. Cs^{134} is slowly disappearing from the Eskimos. A maximum A maximum appears to have been reached in the Cs^{137} in Richlanders; it is about twice the maximum reached in 1959.

This summer's work in Alaska is about to begin. X-ray counting of Pu^{238} in rat urine and feces samples proved a useful technique. The Van de Graaff gave trouble that was never located but finally disappeared.

Biology programs are receiving beneficial use from developed smoke control equipment and an alpha energy analysis air monitor. The smoke control system maintains desired smoke-air mixtures in animal inhalation experiments.

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Work was accelerated on the remote data stations for the HAPO radiotelemetry system. Two stations have been completely modified and fabrication was initiated on five additional stations on an emergency basis.

Attempts were made to nondestructively inspect Elk River Reactor heat exchangers at the request of the Commission's Chicago Operations Office. Although the eddy current tests were limited as a result of undersized tubing, tests did reveal definite suspect defects. Requests for additional tests are expected in the near future.

An analog simulation of the 314 Building high temperature gas loop is in progress, to be used in evaluating the effects of high temperatures on various materials. The basic system equations have been defined and portions of the process simulated. Initial results indicate that one of the major control valves may be improperly sized for optimum operation.

An improved ultrasonic resin level detector has been completed and made ready for late June installation in 202-A Building.

3. Chemistry

Satisfactory partitioning of plutonium from uranium was obtained using sodium sulfoxalate formaldehyde (vice ferrous sulfamate) as the plutonium reductant in a miniature mixer-settler experiment.

Engineering-scale tests of run-away reactions in nitrated anion exchange resins indicate that simple venting systems are adequate to relieve pressure surges.

A decision was reached in conjunction with CPD personnel to proceed with a plant test of immersion heaters as a second generation in-tank solidification unit.

Nitric acid corrosion rates of as-rolled 304-L stainless steel containing 1 wt% boron were almost double those of boron-free 304 L.

An irradiation dose of 6×10^8 r to n-dodecane (generally regarded as the "ultra" diluent for a Purex-type solvent) resulted in alteration of about 40% of the sample but yielded stable saturated hydrocarbons as the major products.

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Recent NMR and infra-red measurements of alkali metal species extracted by the CSREX solvent system are suggestive of the species $M^{+}D2EHP^{-} \cdot 4BAMBP$ as the organic-soluble species.

Gamma irradiation of hydrogen-oxygen mixtures in contact with dry or moist zeolites results in combination of the hydrogen and oxygen to form water. The hydrogen content of the gas phase over a moist zeolite containing ca. 25 wt% H_2O decreased from 48% to < 1% with a dose of 1.6×10^7 r.

Initial measurements of gamma activity in Pu^{238} have revealed 2.61 Mev Te^{208} gamma radiation in amount only slightly less than the Pu^{238} gamma. This is strongly suggestive of the existence of the Pu^{236}-U^{232}-Th^{228} chain in present-day Pu^{238} and, if confirmed, represents a source of gamma background in Pu^{238} that could conceivably be minimized by producing Pu^{238} via irradiation in regions of minimized fast flux and thereby reducing the formation of Pu^{236} by the reaction $Np^{237}(n, 2n)Np^{236} \xrightarrow{\beta} Pu^{236}$.

A sample of isotopically-pure U^{233} has now been obtained via decay of Pa^{233} previously isolated from irradiated thorium.

Further study has been made of spray calcination as a means of converting thorium nitrate solution to an oxide suitable as feed to a Sol Gel process.

The spray calciner product is also being evaluated for its suitability as a direct feed for target fabrication by cold-pressing.

As a result of the discharge of abnormal amounts of mixed fission products to the Gable Mountain Swamp, scintillation probe traverses were made. Quite evident from the survey is the concentration of radionuclides by algae growing on near-surface and shoreline vegetation.

Waste calcination work in the 325A hot cells has been concluded and cleanup and disposal operations are underway in preparation for planned work on waste fixation as glass.

The use of insoluble calcium borate in waste (as a fluxing agent to make "glasses") proved outstandingly successful during spray calcination. A dense product was obtained with no operational difficulties.

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Ruthenium decontamination factors in excess of 100 were obtained by passing Purex acid condensate through a three-cell electrodionization unit containing a 1:2 volume mixture of Dowex 50W-Dowex 1, 20-50 mesh, resin. Equilibrium conditions were not attained when 2600 bed volumes were treated.

For the Containment Systems Experiment, modifications to T-Plant progressed to a condition almost ready for containment vessel erection. Two alternate systems for acquisition and recording of the large amounts of data (including transient pressures, strains and temperatures) as well as sample counting are being considered. Preparations continued for tests to compare and select simulants for fission product aerosols for use in the CSE facility.

Interest in the reopening of the Standard Oil Company of California Rattlesnake No. 1 test well exists in numerous organizations, including USGS, National Science Foundation and Mohole contractors.

The "most promising" dissolution procedure devised to date for PRTR mixed oxide fuels may not be usable in the Redox Plant because of potentially severe corrosion of the steam coils.

In exploratory hot cell studies of Salt Cycle processing of 30 lb lots of irradiated UO_2 fuel, a highly successful by-product electrodeposition was accomplished in which UO_2 was separated from plutonium by a factor of 1000. The high oxygen content (O to U ratio of 2.10) of a mixed UO_2-PuO_2 product recovered in the codeposition step in an earlier run was successfully reduced to an acceptable level (O to U ratio of 2.005) by hydrogen reduction.

Comparison of current low-level fallout samples with samples taken 1 yr ago show substantial differences in relative concentrations of Y^{88} (105 dis), Sb^{124} (60 dis), and Zr^{95}-Nb^{95} (65 dis), implying a fractionation phenomenon or a different source for Y^{88} and Sb^{124} than for most of the Zr^{95}-Nb^{95}.

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In evaluation of candidate methods for analysis of radioisotopes in bio-medical and environmental samples, work continued on methods for cerium and for Po^{210} in soil, urine, and water.

With the added analytical capability that multidimensional analysis provides it has proven possible to use Na^{24} as a river flow tracer. By this technique the travel time from Pasco to Vancouver was determined to be about three days during the period of peak flow of the Snake River.

Progress is being made in development of a completely instrumental method for determination of fuel burnup. By discriminating against all gammas that are in coincidence with betas it is possible to measure Ba^{137}, the daughter of Cs^{137} (a favored burnup index) to ±1% in a 1.5 yr old mixture of unseparated fission products.

Successful high energy pneumatic compactions have been made with strontium sulfide, a candidate heat source of possible interest for burnup re-entry. Strontium hydride and strontium silicide have likewise been synthesized, but their behavior in pneumatic compaction is not yet assessed.

4. Biology

Higher than anticipated mortality was observed in chinook salmon raised in uncooled KE Reactor effluent water. This may be caused by greater sensitivity of the current test fish (Priest Rapids stock) or might possibly be associated with the new zirconium tubes at KE.

Further studies of columnaris antibody clearly indicate that presence of such antibodies may be used as an indicator of earlier exposure of fish to the disease.

A dog exposed 4-1/2 yr ago to $Pu^{239}O_2$ shows radiographic evidence of an enlarging pulmonary tumor. There is also evidence of mammary tumors.

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The protective effect of shielding short segments of the intestine during supralethal irradiation may be due, in part, at least, to the preservation of the mechanism for bile salt absorption. Exposure of rats to 1500 r reduced this absorption to 45% of normal. Shielding a 2 in. segment of the small intestine preserved 67% of normal absorption.

Cliff swallows caught in nets disgorged their insects. Collecting these disgorged insects provides a unique method of determining food habits of the birds and radionuclide intake of the young; the food chain from river to young birds may be analyzed by this method.

An extensive series of tests on the uptake of iodide by plants yields data that are most easily interpreted in terms of metabolic uptake and translocation process.

5. Programming

Hanford fuel cycle codes will be applied to predict the economics and uranium conservation aspects of two alternate fuel cycles (i. e., U^{233}-Th; U^{235}-Pu-U^{238}), as well as intermixtures of these various fissile-fertile species.

TECHNICAL AND OTHER SERVICES

There were no new plutonium cases confirmed by special bioassay analysis during the month. The total number of individuals who have received internal plutonium deposition at Hanford is 344. With the reactivation of one employee and the termination of three employees having confirmed plutonium depositions, there are currently 245 individuals employed at Hanford who have received a detectable internal plutonium deposition.

Two process swamps that receive cooling water from the Purex Plant became contaminated on June 12 as the result of a failure of a cooling coil in a concentrated waste sampling tank. Current estimates indicate that some 10,000 curies primarily Zr-Nb^{95}, Ce^{141}-Ce^{144} and Ru^{103} entered the swamps. The radioactivity has remained in the swamps and access to the swamps has been controlled to limit exposure to personnel.

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Transit water fowl that might carry the contamination off project are not migrating through the area at this season, and control measures to prevent their contamination should be completed before the flights arrive.

A fuel element placement pattern was devised to aid in comparing treatments resulting from a 2X3 factorial test. Variable factors were oil or water quenching versus α-annealing, pre-AlSi dipping, or regular canning.

A design for a production test comparing 12 treatments was prepared to investigate the dimensional-distortion performance of depleted uranium fuel elements. The design used the property that the sequential placing of columns from a latin square will eliminate the effects of a linear gradient (hence the radiation effect) on warp.

A statistical analysis of adult progeny data from X-ray exposed Tribolium Castaneum was initiated. The purpose of the study is to investigate the effects that different levels of X-ray exposure to one or both members of a mating pair and temperature have on the number of adult progeny produced.

Two reports were completed by the HL Computer Task Force. These reports discuss tentative computer configurations suggested by several digital computer manufacturers and the current level of service provided to Hanford Laboratories by EDPO.

The AEC is about to launch a full scale study of the impact of its facilities on the national economy. As a consequence there will be a study of the Tri-City Area. At the request of RLOO, work has begun analyzing the elaborate AEC questionaire and planning the required survey.

The most recent version of the Linear Program LP/90 as distributed by SHARE has been made compatible with HAPO EDP equipment, and has been successfully employed by IPD personnel.

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SUPPORTING FUNCTIONS

PRTR output for June was 903 Mwd for an experimental time efficiency of 59% and a plant efficiency of 44%. There were six operating periods during the month, three of which were terminated by scrams and three were terminated manually. A summary of the fuel irradiation program as of June 30, 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		7	1586.0	78	11723.6			85	13309.6
Maximum				303.8		302.6				
Average				226.6		150.3				
In-Basin	7	572.5	25	2673.1	40	3768.3			72	7013.9
Buried							1	7.3	1	7.3
Chem. Process.	68	5465.8	35	1965.8					103	7431.6
Program Totals	75	6038.3	67	6224.9	118	15491.9	1	7.3	261	27762.4

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

Indicated helium loss for June was 134,876 scf. Heavy water loss for June per physical inventory was 73 lb (adjusted).

On June 22, 1964, 20,611 lb of scrap heavy water were shipped to Savannah River.

A total of 138 reactor outage hours was charged to repair work. Main items were:

Shim rod replacement
Rupture Loop repairs
"B" dump valve repair
D_2O leak repairs
Pressurizer float switch repair
Moat rupture disc replacement

Measurements of fuel worth, void worth and the worth of selected absorbing materials at various core positions in the Plutonium Recycle Critical Facility were completed. Irradiations for measurement of the neutron spectrum and for flux distribution in the core were performed. Preliminary temperature coefficient of reactivity data were obtained.

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The Rupture Loop in the Fuel Element Rupture Test Facility was removed from service on June 14, 1964, when it was found that the mixed bed ion exchange unit had failed and introduced loose resin into the main piping. The loose resin has been flushed out, ion exchangers have been refilled, and the jumpers fabricated. At month-end, the Rupture Loop was ready for preoperational testing.

Further chemical analyses of the PuO_2, which was received during the April Redox Campaign, has shown ~ 2 ppm boron contamination. The material has been accepted for fabrication.

Technical Shops Operation total estimated productive time for the period was 25, 352 hr. Estimated distribution of time was as follows:

	Man Hours	% of Total
N-Reactor Department	2, 307	9. 1
Irradiation Processing Department	4, 411	17. 9
Chemical Processing Department	634	2. 5
Hanford Laboratories	17, 998	71. 0
Hanford Utilities & Purchasing	2	nil

Laboratory Maintenance Operation total productive time was 18, 700 hr of 21, 200 potentially available. Of the total productive time, 92% was expended in support of Hanford Laboratories components, with the remaining 8% directed toward providing service for other HAPO organizations. Manpower utilization (hr) for June was as follows:

A. Shop Work		2 100
B. Maintenance		7 100
1. Preventive Maintenance	2 000	
2. Emergency or Unscheduled Maintenance	1 700	
3. Normal Scheduled Maintenance	3 400	
C. R & D Assistance		9 500

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The heavy water inventory at the end of June 1964 showed a loss of 700 lb valued at $9, 681 for the PRTR. Heavy water scrap generated during the month amounted to 2308 lb, resulting in a $4, 966 charge to operating cost. Heavy water returned to SROO amounted to 20, 611 lb with a fund value of $256, 234 and a nonfund value of $127, 266. Total scrap on hand at June 30, 1964 amounted to 2, 776 lb values at $32, 822.

Cumulative data of Hanford visitations:

	Number of Visitors	
	In June	Since 6-13-62
Visitors Center	4 113	71 921
Plant Tours	106	---

Attendance during the celebration of the second anniversay of the Visitors Center June 12, 13, and 14 was 1, 404.

Forty thousand people visited the Richland booth at the Washington Community Festival in Seattle.

HAPO professional recruiting activity for June:

	Plant Visits	Offers Extended	Offers Accepted	Offers Rejected	Offers Open
Ph. D.	11	7	5	5	5
BS/MS (Direct Placement)	0	5	6	1	-
BS/MS (Program)	0	2	2	1	4

Fourteen Technical Graduates were placed on permanent assignment, and 15 new members were added. Program strength at month end totaled 46.

Authorized funds for 11 active projects total $10, 520, 500. The total estimated cost of these projects is $11, 308, 500. Expenditures through May 31, 1964 were $3, 495, 665.

Manager, Hanford Laboratories

HM Parker:JEB:da

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REACTOR AND FUELS LABORATORY MONTHLY REPORT

JUNE 1964

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 02 PROGRAM

1. Metallic Fuel Development

Comparative Swelling of Uranium Alloy Fuels. Eight KSE-5 fuel elements were discharged from KER Loop 2 after attaining an average exposure of approximately 1400 Mwd/ton. The loop charge consisted of alternately loaded fuel elements containing uranium with low iron and silicon additions (N-fuel composition) and elements with approximately 400 ppm iron and 800 ppm aluminum as additives, (British fuel composition). The volume mean fuel temperatures of these elements ranged from 524 to 525 C over the length of the charge with maximum fuel temperatures near 600 C. Fuel swelling data obtained from pre- and post-irradiation bulk densities measurements show a significant difference in swelling behavior of the two fuel compositions with the iron-aluminum additive fuel showing consistently less swelling. The peak fuel swelling of the iron-aluminum containing fuel was 1.2 vol% compared to the peak swelling of the N-fuel of 2.1 vol%.

A similar charge of eight KSE-5 fuel elements of these two compositions, currently being irradiated to a goal of 2500 Mwd/ton, will provide additional data on the effect of iron-aluminum additives on fuel swelling.

N-Reactor Fuel Evaluation. Post-irradiation radiometallurgical examination of both the inner and outer components of a high exposure N-Reactor fuel element has been completed. The outer component was irradiated to 3070 Mwd/ton and incurred 3.64 vol% swelling and the NIE attained 2440 Mwd/ton exposure and incurred 1.17 vol% fuel increase. No evidence of inadequate cladding, bond, or closure performance was observed. Void formation resulting from "grain boundary tearing" was found in the fuel of the outer component. The relatively large number of irregular pores present in the fuel indicates that "grain boundary tearing" was a major factor contributing to the observed swelling.

Post-irradiation nondestructive testing of N-fuels irradiated in KER loops has given indications of possible defects in the closures of two outer fuel tubes (NOE's). Superficial examination of one of

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these elements in Radiometallurgy failed to show evidence of a surface defect or irregularity. Destructive examination is in progress.

Fluted Fuel Element Irradiation. Two N-single tube fuel elements with fluted outer surfaces are in their 12th cycle of irradiation in the ETR M-3 pressurized loop. After an accumulated exposure of approximately 2200 Mwd/ton, the elements had undergone a volume increase of 2.3%. These elements are operating with a maximum specific power of 140 kw/ft and a corresponding fuel temperature of 550 C.

Fuel Element Measurements. A comparison of density and dimensional data was made for the KER K-4-13, 14, 15, and K-3-18 N-fuel charges. A good correlation was found between the percentage volume change and percentage cross-section area change for the NOE components. A reasonably good correlation between percentage change in volume and percentage change in the OD was found for those NIE components having greater than 0.4% swelling. In both cases the data were uncorrected for fuel element length changes, and it can be expected that these corrections would further improve the correlation of data obtained from the two separate measurement techniques.

Analysis of pre-irradiation density data show that bulk fuel element densities of both the inner and outer components were constant within 0.54% on a 95% confidence limit. This constant pre-irradiation density can be used as a separate check on other measurement techniques.

KER Co-producer Test. Thirteen 1.25% enriched driver elements and their companion aluminum-lithium target elements were discharged from KER Loop 3 after attaining an average exposure of about 1300 Mwd/ton. Four driver elements in the center of the charge swelled in excess of 2 vol%. A maximum fuel swelling of 3.3 vol% was observed in a fuel element which operated with a maximum fuel temperature of approximately 530 C to an exposure of approximately 1850 Mwd/ton. A fuel swelling of 3.6 vol% (at 2000 Mwd/ton) was predicted on the basis of previous KER fuel irradiation data.

Pre- and post-irradiation density measurements made on the 13 target elements revealed no evidence of swelling in the target alloy. The Zircaloy-4 can from one target element was stripped without evidence of bonding. The densities of sections of the target core from this element were determined and did not differ significantly from the pre-irradiation values. In addition, no changes in the diameters of the Zircaloy cans were detected as a result of irradiation.

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Target Element Development. Examination of the target elements irradiated to high exposure in KER Loop 2 has continued. Zircaloy-4 samples from the "bonded" areas analyzed 0.03 ppm tritium, which is not significantly different from the tritium content of nonbonded areas. Thus, the "bonded" regions did not effect the transport of tritium to the Zircaloy can.

As part of the program for the evaluation of the irradiation performance of alternate target materials, the following target materials have been fabricated as test elements and charged into a KER test loop:

1. 40 vol% $LiAlO_2$ - 60 vol% Al
2. 50 vol% $LiAlO_2$ - 50 vol% Al
3. 40 vol% Li_2SiO_3 - 60 vol% Al
4. 50 vol% Li_2SiO_3 - 50 vol% Al
5. Li_2SiO_3
6. $Li\ AlO_2$
7. 50 wt% $LiAlO_2$ - 50 wt% Li_2SiO_3
8. 14 wt% Li-Mg alloy.

Co-producer Target Elements. The first co-producer production test in the N-Reactor will involve nearly 800 elements. These elements consist of an outer driver fuel element and an inner target rod. Fabrication responsibility for the target components rests with Hanford Laboratories, the driver elements with NRD, with scheduled reactor charging by August 1, 1964. To date, the target element fabrication is over one-third complete. Over 10,000 supports were welded onto the Zircaloy shells. These shells have been autoclaved to provide a protective outer surface against water corrosion and an aluminum diffusion barrier on the inner surface. The machining, assembly, and welding of 240 billet shells and cores were completed ahead of schedule. These billets were coextruded into 1/2" diameter rods with various cladding thicknesses to give a constant Li^6 distribution per unit length of element. Barring unforeseen difficulties, the delivery of these elements is expected to be on schedule.

Coextrusion of N-Target Material. The extrusion of 227 billets of C-64 aluminum clad Li-Al target material for the N-Reactor charge has been completed. The extrusions were made at a 20 to 1 area reduction, and the resulting surface finish and unbonded interface between core and clad appears very good.

The use of an Aquadag coated billet and a Bentonite grease containing lead fines drastically reduced the frequency of extrusion die pickup. A sand blasted or vapor blasted surface prior to the

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application of the Aquadag on the billet was found also to be very effective in preventing the aluminum from galling to the die.

A number of coextrusion billets was extruded prior to the beginning of the N-target element extrusion run to arrive at a billet preheat temperature and an extrusion speed which would insure unbond between clad and core while providing a good surface finish on the extrusions. Based on the above results, the billets were preheated to 175 C and extruded at a die exit speed of 600 inches/minute.

Work is being planned to coextrude Al clad 3% Li-Al from the 4-inch container at a reduction of 50 to 1 in an effort to determine if a set of conditions can be arrived at which will prevent bonding at this reduction. Success of this test will enable future N-target material to be extruded from the 4-inch container on the product department extrusion press.

Target Element Fabrication. Fabrication of target elements for N-Reactor required an assortment of welded joints. The Zircaloy outer cans for the elements have supports attached by resistance welding. These have been completed--approximately 20,000 welds. Every weld has been recorded on the Brush oscillograph. After every third element (54 welds), a sample piece was run with a weld for tear testing, two welds for shear testing, and two welds to be used for alternate tests as required. When 180 elements (3240 welds) had been run, this was reduced to a test piece after every fifth (90 welds) element. This was later reduced to one test piece after 10 elements.

The billets for extruding the aluminum-lithium cores have been closed by welding. The billet can is machined from aluminum tubing. A bottom is welded in cans degreased, and after loading, a top is welded on. This operation was carried on manually using a turntable. Welding was done using DC with helium shielding gas. The operator had manual control of the current and billet rotation. The torch was hand held.

Capsule Irradiation of Uranium Alloy Swelling Studies. Seven ingots have been consumable arc melted in support of the above program. Variables include composition, heat treatment, and melting history. The uranium raw material is 1.47% enriched and is divided into dingot uranium (low carbon) and ingot uranium (500 ppm carbon). Heat Nos. 170, 171, and 172, Table I, were vacuum induction melted in the 306 Building from the ingot

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material. These were extruded and remelted in the consumable arc furnace.

Heat No. 173 was double vacuum arc melted from the ingot uranium. Heat No. 174 was single vacuum arc melted and will be further diluted by remelting in the vacuum induction furnace. Heat Nos. 175 and 176 were arc melted from billet stock received from Mallinckrodt. Original plans called for this material to be heat treated and coextruded without arc melting; however, attempts to beta heat treat the billets produced severe cracking and salvaging of the material was necessary.

TABLE I

ARC CAST URANIUM ALLOYS

Heat No.	Weight, lbs.	Composition, Aim ppm Fe	Si	Al	C	Wt% Mo	Zr	Remarks
170	68	400		800	500			Vacuum induction cast and arc cast.
171	55	175	85	100	1000			Remelt.
172	65		800		500			
173	41						2.0	Double arc melted.
174	58					6.0		Arc cast master alloy for vacuum induction remelt.
175	55			800	Low			Cracked, Mallinckrodt billets, dingot, arc cast remelt.
176	91		300	260	Low			

Alternate Uranium Composition. Studies are in progress to determine the effects of altered fuel compositions upon fuel element fabrication, corrosion behavior, and irradiation swelling resistance.

Samples of 1.47% enriched uranium base fuel alloys fabricated to 0.600-inch diameter Zr-2 clad rods were heat treated in both the beta and gamma phases and are being examined for structure evaluation. Three alloys; U + 1.75 wt% Zr + 700 ppm Al, U + 1.55 wt% Zr + 80 ppm Si, and U + 1.70 wt% Nb + 380 ppm Al; were observed to have inclusions that formed from the melt and were insoluble in the solid. Sections of these were examined by Ferguson at MCW with the electron microprobe and the inclusions qualitatively identified. In the case of the U-Zr-Si alloy, the inclusions contain U, Si, and Zr in a ratio of about 10, 15-20, and 70, respectively. The inclusions in the U-Zr-Al

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alloy contain no uranium, only Zr and Al, and are a high percentage Zr. In the U-Nb-Al alloy some Nb-Al inclusions were noted and some inclusions identified that contained Nb only. Other massive inclusions were not identified but did not contain Nb or Al and are presumed to be UC or UN. There is no explanation for the high carbon or nitrogen at this time and no indication of this from the chemistry of the material.

Identification of Irradiated Fuel Elements. Currently, enriched fuel elements are distinguishable from natural uranium elements in the pickup basin after discharge by difference in length. This method of differentiation is inherently expensive, and different methods are being examined.

Preliminary tests were run to determine whether surface marks shallow enough to pass acceptance specifications could be seen and recognized under the lighting and operating conditions normally obtained at the pickup chutes. Surface markings tried included coarse and fine knurls, circumferential grooves, spiral indentations, and sand blasted surface. None of these could be distinguished at the bottom of the basin.

It was suggested that Zircaloy does not normally become encrusted with film during irradiation as aluminum does, and it seems possible that a band of zirconium plated on the aluminum jacket might show up after the element is irradiated as a darker or lighter area than the remainder of the jacket. As a preliminary test, three aluminum dummy slugs were banded with a thin shell of Zr. These are to be placed in flow loops in the reactor areas, where water composition and temperature are the same as in-reactor and where it is known that the film normally forms on aluminum jackets. If these samples show a difference in appearance between the Zr and Al surfaces, placement of Zr by plating will be studied.

Fuel Fouling Detector. The thorium-fueled fuel fouling probe, which was discharged from KER Loop 2 after receiving 1000 Mwd/ton, is being examined in Radiometallurgy. No deficiencies in irradiation performance have been observed.

A second fuel fouling detector continues to operate satisfactorily in KER Loop 4.

Welding. Twelve of the 20 N-Reactor outer element sections closed by resistance projection welding have been put in the 400 C, 1500 psi steam autoclave. Examination of micro sections of three welds indicates that the phonograph finish cap may well be superior

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to the previous projection design. This cap is machined with a 60° tool 0.010" cut with 0.020" feed. This produces a phono finish which is then removed in areas where bonding is not desired. Examination also confirmed suspected machine misfiring in one case.

Electron Beam Evaporator. A new and more economical process has been developed for the placement of copper on end caps used in the hot-headed and projection welded end closure. The old process involved machining the caps, immersion plating with copper, and remachining, with a high reject rate on finished caps. The new process deposits a much higher quality and cleaner copper film by vacuum evaporation through a special mask, leaving the deposit only on the required areas of the cap. With this process it is possible to use caps that are machined or coined to final dimensions, eliminating at least one machining step. In the process developed, the copper was deposited at the rate of 1 mil/hr at a vacuum of 10^{-6} Torr and a power level of 5 kw. Five-tenths mil of copper was deposited in the first run, but other thicknesses will be tried to determine the optimum for the closure. It is suspected that 0.1 mil or less may be adequate.

K-5 Fuel Charging Force Studies. Friction coefficients, associated with charging K-5 fuel elements into Zircaloy-2 process tubes, were used as the basis for evaluating charging behavior of three K-5 fuel support configurations. Bridge rails, aluminum tie sections, and split weld arch rails were evaluated. No significant advantage was noted for any particular rail type as far as charging forces are concerned. Average friction coefficients, with water lubrication and supports in the 45° orientation (gravitationally stable position), are 0.54 for present bridge type rails, 0.55 for the proposed tie section, and 0.50 for the proposed split weld arch rails.

N-Reactor Fuel Support Development. The mechanical properties of modified N-inner supports are being investigated. The effect of the strip width dimension on the properties of individual supports and the support assembly is being determined. Modification of the inner supports to a narrower width is being considered because of the possible necessity for increased coolant flow in the annulus occupied by the inner supports.

Dual Purpose In-reactor Capsule. The capsule containing aluminum-lithium, ceramic, and cermet targets and a zirconium oxidation and hydriding capsule was discharged from K-East after 56 days at full reactor power. The capsule is being disassembled in Radiometallurgy

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Laboratory. So far, only the ceramic and cermet targets have been removed. There was no obvious distortion of the aluminum cladding of other targets.

Outgassing data were taken at several temperatures, 360-410 C (680-770 F), from the lithium-aluminum target with the reactor in operation and at several temperatures, 300-370 C (572-698 F), during reactor shutdown to establish the flux effect and determine the temperature coefficient for tritium evolution.

2. Corrosion and Water Quality Studies

Process Assistance for IPD Reactors. The effects of methods of heat treatment on 304 stainless steel sheaths of resistance temperature element were investigated in regard to resistance to stress cracking susceptibility in boiling $MgCl_2$ solution. Cracking started in one to four hours on an as-machined specimen, in 4-1/2 to 6-1/2 hours for specimens treated 48 hours at 800 F, and in 41 to 100 hours for those treated two hours at 1200 F. Specimens heat treated for one hour at 1850 F and cooled in furnace, still air, or air blast showed no cracking during the 547-hour test. The use of stainless steel sheaths is being investigated as a possible means to eliminate pitting of the present Inconel sheaths.

Crud Deposition on Fuel Elements. Zirconium-clad fuel elements exposed in two stainless steel loops to high temperature, pH 10 ammoniated water were visually examined following their recent discharge. The KSE-5 elements from KER-2 were covered with a dull black film similar to magnetite in appearance. Unheated zirconium rods, used as flow splitters, had the same appearance. There was no variation with position in the fuel column. The NOE elements from KER-3 had a dull red-brown film that appeared very patchy. Flow patterns were observed behind the supports. The unheated target elements inside the NOE's had a black ZrO_2 film with very little crud. The films on both these charges were considerably different from the bright reddish-brown films observed on elements discharged from a carbon steel loop (KER-1) operating at the same temperature and water quality. The results may also be distinguished from previous experience in the same two loops with pH 10 lithiated water in which black shiny ZrO_2 with no crud deposit has been observed on most discharged fuel elements.

Radiolysis of Ammonia in Coolant. Measurements were made of the rate of loss of ammonia from the N-Reactor primary coolant by radiolysis during low power, high temperature operation with

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ammoniated water at pH 10.1. The loss rate was 21-lb NH_3 per day or 26% of the injection rate. This loss rate may be compared to 22-30% found in several measurements in the KER loops operating at a comparable feed-and-bleed rate.

Carbon Steel Corrosion in Ammoniated Coolant. A significant reduction in corrosion rate with time has been observed in tests of the corrosion of carbon steel coupons exposed at 300 C in the TF-1 and TF-4 ex-reactor loops to pH 10 ammoniated water. Rates between 200 and 1000 hours averaged 0.32 mil per year; these fell to 0.15 mil per year between 1000 and 2200 hours. The average rates of film buildup also fell off during the same period of time, from 53 mg/dm^2mo to 26 mg/dm^2mo.

Corrosion of Copper Alloys by Ammonia. Samples of stressed commercial bronze were exposed in both the liquid and vapor phases of refluxed pH 9.0 NH_4OH solutions at 200 F and room temperature for one month. Stress corrosion cracks approximately 2 mils deep were observed on the samples exposed in the vapor phase at 200 F. In another set of tests, copper tubing and commercial bronze fittings were exposed in the liquid phase of pH 10 NH_4OH at 200 F and room temperature in a refluxed system. Large amounts of black corrosion films were observed on the samples and some tuberculation (indicating pitting was occurring) was observed. Metallographic examination is being conducted.

N-Reactor Steam Generator Tubing. Work was continued to determine the possibility that residual pickling acid (HNO_3-HF) in the steam generator tubing during fabrication could cause intergranular attack. Acid droplets of various concentrations were placed on strip samples. Some of the strip samples were kept in a relatively moist atmosphere to simulate the environment inside the tubing; these samples developed a light-green corrosion product at the acid treated areas and at other areas where condensation occurred. All samples were charged into a heat treatment furnace to simulate annealing and sensitization heat treatments. Following the heat treatments, the samples were wetted with Chattanooga City water and stored in a moist water atmosphere. Extensive corrosion products developed at the treated areas. Metallographic examination at the corroded areas has revealed intergranular attack as deep as 10 grains after only two weeks of exposure in the samples subjected to the relatively moist atmosphere following acid treatment.

Chemonuclear Studies. Aqueous solutions of ammonium hydroxide were irradiated in the in-reactor single-pass facility to study

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the formation of hydrazine. The tests were conducted at 1000 psia pressure and about 20 C. With initial (inlet) ammonia concentration of 800 to 850 ppm, 350 ppb hydrazine was produced with a 25-minute in-flux holdup time, 450 ppb with 45 minutes, 330 with 91 minutes, and only 53 with 245 minutes. Only a 2 ppb or less of hydrazine was produced in similar tests with 30 ppm ammonia feed. Extensive decomposition of ammonia to N_2 and H_2 was encountered. The conversion ratio (moles of N_2H_4 formed per mole NH_3 decomposed) increased from 5×10^{-5} to 5×10^{-4} as the ammonia concentration was increased from 30 to 800 ppm. The conversion ratio decreased as the holdup time was increased. The hydrazine content of the product samples fell off with time (from 450 ppb to 230 ppb after one day and 5 ppb after 10 days), indicating the hydrazine is unstable.

One test was conducted with 3% boric acid to study the effect of alpha radiation. With 50 ppm ammonia and 22 minutes holdup, 16 ppb hydrazine was produced. The conversion ratio was 4×10^{-3}. Although not conclusive, this indicates that alpha radiation gives much better yield than gamma and fast neutron radiation.

One test was conducted to study the production of hydrogen peroxide from deionized water. A product concentration of 10 ppm was obtained with a 280-minute holdup time.

3. Gas Atmosphere Studies

Effect of Thick Films on Hydriding of Zircaloy. The oxidation of heavily prefilmed (50-500 mg/dm^2) Zircaloy-2 samples in helium containing H_2, CO, and H_2O is reduced by the presence of the bulk film, allowing hydriding to take place. Variation of hydrogen partial pressure in the gas mixture indicates a pressure effect on hydriding, as well, for thick filmed samples. Under conditions in which the oxide film on Zircaloy is permeable to hydrogen, the hydriding rate is dependent on the hydrogen partial pressure.

Graphite-Zirconium Compatibility Loop Experiment. A third oxidation test in the compatibility loop was made at 820 C with an inlet gas composition of 200 ppm H_2O, 1000 ppm H_2, and 1000 ppm CO in helium. Surface oxidation rates were 0.6 to 1.8×10^{-6} g/g-hr and interior rates 0.2 to 1.0×10^{-7} g/g-hr (cf. HW-82428 A, p. A-9).

Certain trends were observed along the length of the bar and across the bar. A new oxidation bar, now in the loop, was designed to more adequately study these effects.

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4. Process Tube Development

Irradiated Tube Testing Facility. Three of the five new furnace containment vessels have been tested, utilizing unirradiated sections of N-Reactor tubing. Temperature uniformity within 3 C (37 F) was obtained from top to bottom on these sections.

Three additional irradiated KER tube sections were burst tested during the past month. Test results are being analyzed.

5. Thermal Hydraulic Studies

Thermal Hydraulic Characteristics of N-Reactor Fuel Columns. Analyses were continued of laboratory experiments using an electrically-heated, full-scale model of the downstream half of an N-Reactor fuel column. The results of the study will be used in hazards analyses and establishment of thermal hydraulic operating limits for N-Reactor.

Equations were developed to allow extrapolations of the laboratory data concerning flow and pressure drop to pressure conditions other than those run in the experiments. This was done by relating the ratios of two-phase to liquid-phase pressure drops to the ratios of two-phase to liquid-phase specific volumes for the various portions of the fuel column. The equations fit the experimental data within 10% and allow construction of flow pressure drop curves for all or various parts of the N-Reactor fuel column and outlet piping from conditions of all liquid flow to those at which boiling burnout would be expected to occur.

Calculations were made to determine the effects on the pressure drop data of using a "stepped" cosine heat distribution (rather than a pure cosine heat distribution) in the laboratory test section; although the steam quality distribution along the length of the test section would be somewhat different, it was found that the over-all pressure drop across the fuel column would not differ by more than 2.5%.

Calculations were also made to determine the effects on flow trips of using orifices to limit flow rates in the fringe zones of the reactor. It was found that orificing a tube would require closer trip settings to cause a reactor shutdown in case of boiling burnout conditions occurring in one of the individual flow channels of the fuel element column. Representative curves of trip settings required to prevent boiling burnout conditions were prepared. These curves will be presented in the report (HW-80692) of the steady state results of the laboratory experiments performed for the N-Reactor.

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Hydraulic Tests for Present Production Reactors. Tests were performed in the hydraulics laboratory to determine the fluid flow characteristics of an improved fuel support design for the KVN and KVE I&E fuel charges in a K-Reactor Zircaloy-2 process tube. The standard rail which is presently in use presents a flat face perpendicular to the annular coolant flow passage causing undesirable pressure losses between the upstream and downstream portion of the fuel column. The modified rail, when viewed parallel to the flow stream, forms an arch, thus permitting coolant flow through the length of support rail.

Reduction of the flow resistance in the annular region of the fuel and tube assembly through the use of the modified support rails would permit an approximate flow increase of 6.8% with the KVN fuel and 8.0% with the KVE fuel at the present front header and rear header operating conditions.

Operation of the Heat Transfer Apparatus at 3800 KW. A test was performed to verify the capacity of the electrical rectifying equipment and the heat transfer apparatus to operate for extended periods of time at heat transfer rates of 3800 KW. A 20 feet long, tubular type test section was used to generate 3860 KW (125 VDC at 30900 amps) for a period of five hours. During this time special recordings were made of the oil and winding temperatures of the saturable reactor and the two transformers since these components would limit the apparatus from continuous operation above 2700 KW. Extrapolation of the temperature readings indicated that the equipment could be operated at 3860 KW for at least 12 hours without exceeding the continuous temperature rating of the equipment.

6. Shielding Studies

N-Reactor Shield Evaluation. Reduction and analysis of the N-Reactor shield data are continuing. The Li^6 detectors were again calibrated and irradiated at the PCTR. This irradiation confirmed analyses and indicated that background subtraction is not necessary for the Li^6 detector. The N-3 power ascension irradiation has begun.

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.

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C. REACTOR DEVELOPMENT - 04 PROGRAM

1. Plutonium Recycle Program

Fuels Development

Water Tube (Inverted Cluster) Fuel Element. A full length, vibrationally compacted UO_2, Mark IX-B water tube (inverted cluster) fuel element was successfully irradiated in the PRTR Fuel Element Rupture Test Facility. This test is the first of a long (97 inches), internally cooled element. Maximum tube power of 356 kw was achieved at 40 mw reactor power before the test was temporarily interrupted by failure of the FERTF ion exchanger. Post-irradiation examination showed the element is in excellent condition. A second assembly is being fabricated.

PRTR Fuel Element Performance. Post-irradiation examination of the incrementally loaded, swage-compacted, UO_2-0.5 wt% PuO_2 PRTR fuel element (F.E.-5168) that failed at an exposure of 5120 Mwd/ton revealed internal corrosion and penetration of the Zircaloy cladding. This failure, the first of its type observed at Hanford, is characterized by lack of fuel swelling; a small (0.025 mm), highly branched, radially oriented pinhole penetration through the cladding; and, no hydride precipitation. Similar appearing failures of Zircaloy-clad UO_2 elements of like exposure experienced recently at APED are tentatively attributed to interaction between fission product iodine and Zircaloy.

Cladding Evaluation. Tests were initiated to determine the effect of stable fission product iodine on Zircaloy-2 cladding. Recent unusual cladding failures at 5000 Mwd/ton or greater at GE-APED and at HL may have been caused by that interaction.

Several sealed Zircaloy bombs containing I_2 equivalent to that formed in 300 PRTR operating days, and water sufficient to produce an internal pressure of 1800 psig were autoclaved six days in 400 C, 500 psig steam. The pressurized bombs were stressed to 9700 psi, or approximately 30% of yield strength. Although no corrosion failures were observed, white oxide was produced on the Zr-2 exposed to iodine. Water may have affected the reaction, so the test is being repeated using inert gas pressurization for stressing the Zr-2.

A full-length, swaged UO_2 fuel rod containing 165 mg I_2 was fabricated for in- and ex-reactor testing.

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Hydriding of PRTR Fuel Elements. Two end cap sections from unfilled PRTR fuel rods were hydrided in an argon-8% hydrogen atmosphere. Catastrophic hydriding below the end cap was observed in one of the two samples after 16 hours at 425 C. Metallographic examination of the two samples indicated an apparent greater tendency for hydride formation in the crevice region, although actual failure of the one sample occurred outside the region.

Irradiation Testing of EBWR Prototypic Fuel Rods. Irradiation of 22 short rods containing vibrationally-compacted, impacted UO_2-1.5 wt% PuO_2 EBWR fuel continued. Ten similar specimens (five with plenums) are being destructively examined after irradiation to 2.0×10^{20} fissions/cm^3 (7100 Mwd/ton UO_2).

Extensive columnar grain growth and a central void was observed in a test specimen (with plenum) that had generated a calculated surface heat flux of 315 w/cm^2 (10^6 Btu/hr-ft^2). The end of the stainless steel plenum spring had reacted with the ZrO_2 pellet and/or the fuel. An identical test rod that generated 158 w/cm^2 (calculated) incurred no reaction or other change of either the spring or ZrO_2 pellet. An autoradiograph showed that no diffusion of fission products occurred at the ZrO_2-fuel interface.

A test rod (without plenum) that generated 25 w/cm^2 (80,000 Btu/hr-ft^2) showed no grain growth or sintering. An identical test rod developed slight indications of sintering at the fuel center line during irradiation to 0.40×10^{20} fissions/cm^3 (1520 Mwd/ton UO_2) at an estimated surface heat flux of 113 w/cm^2 (360,000 Btu/hr-ft^2). Fourteen percent of the krypton and xenon was released. A third capsule, operated at a heat flux of 337 w/cm^2 (1.07×10^6 Btu/hr-ft^2), developed columnar grain growth over 75% of the cross sectional area, and autoradiographs revealed the expected well defined regions of high and low radioactivity levels and solid solution formation.

Wire Enriched Fuel Element. Analysis of microsamples from a transverse cross section of the plutonium wire enriched fuel element (GEH-4-88) showed the plutonium, originally introduced as 0.102 cm (0.040 inch) diameter wire, became uniformly distributed throughout the center half of the fuel during irradiation. Plutonium concentration in the enriched region is approximately an order of magnitude greater than that found in the outer volume of fuel. Fission product distribution is similar to that observed in UO_2 fuel elements.

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PRTR Fuel Fabrication. Study of Nupac (high energy rate pneumatic mechanical impaction) process variables continued, using mixed oxides with closely controlled oxygen-to-uranium ratios. A new strain gage system using the bending beam principle was successfully used for quality control; it correlates the fuel density of the mixed oxide with the impaction characteristics of the Dynapak machine.

Pneumatic Impaction of UO_2. A recent batch of UO_2 prepared from metallic uranium for use in EBWR loading failed to meet the density specification after pneumatic impaction. X-ray diffraction analyses revealed a second phase, tentatively identified as UO_{2+x}. Specified density can be achieved after the foreign phase is eliminated by a heat treatment in wet hydrogen. It is now hypothesized that the UO_{2+x} phase is concentrated in the center of the UO_2 particles. Decomposition of the UO_{2+x} during pre-impaction heating probably forms gas bubbles that prevent densification to the required 99% TD.

Pneumatic Impaction of Mixed Oxides. Eight hundred and thirty-four kilograms of mixed oxide were compacted by the Nupac process. Of this amount, 750 kilograms were for the EBWR, 48 kilograms for the PRTR, and 42 kilograms for the PRCF fuel program.

PRTR Fuel Element Fabrication. Fuel assemblies fabrication for the PRTR included three 1% mixed oxide elements and three 1/2% mixed oxide elements to be used for test purposes other than PRTR irradiation. The three special test elements contain 7.7, 13.61, and 17.8% Pu-240, respectively, and will be used in the PRCF.

Inclusions have recently been detected in swaged fuel rod cladding. Preliminary investigations have not indicated the source; the swaging machine was completely disassembled for inspection, cleaning, and replacement of any worn parts.

Corrosion and Water Quality Studies

In-reactor Corrosion of Zircaloy Fuel Cladding in PRTR. A test has been approved in which a Zircaloy rod supporting Zr-2 and Zr-4 sample rings with various pretreatments will be attached to a standard moxtyl fuel element cluster and charged into PRTR in July 1964.

Corrosion of Rupture Monitoring Tubing. A pressure test of 1/4-inch stainless steel tubing connecting the HX-5 to the rupture monitor indicated a leak. Five closely spaced cracks in the tube in the

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leak area, originating on the outside of the tube, appear to be stress corrosion cracks caused by chloride from an unidentified source.

Irradiation Effects on the Corrosion of PRTR Zircaloy-2 Process Tubes. Metallographic examination of a discharged PRTR Zr-2 pressure tube, exposed 200 days at water temperatures in excess of 400 F (233 C), indicates oxides equivalent to 41 mg/dm^2 weight gain for both ID and OD surfaces. Oxide thickness was independent of flux density in the range $4 \times 10^{12} - 2 \times 10^{13}$ nv fast (> 1 Mev). In the absence of radiation, weight gains of 21 mg/dm would have been expected, including an estimated 16 mg/dm^2 from the original autoclave film. Metallographic estimation of oxide film from the unirradiated downstream end of the process tube is 21 mg/dm^2, in agreement with the film thickness interpolated from ex-reactor corrosion curves.

Borescope Inspection of the PRTR Top Shield and Calandria. A visual inspection of the carbon steel tube through the top shield, the aluminum shim sealing gasket face, some of the external portion of three aluminum shroud tubes, and the top of the aluminum plenum plate was made by insertion of a borescope through a shim hole. Heavy rust was observed in the top shield hole which had spalled, depositing on top of the calandria. The shim gasket face was completely covered with rust. There was a dense oxide on the shroud tubes above the water line; a reddish deposit was observed below the water line.

Inspection of PRTR Deaerator. Pit depth measurements on the PRTR deaerator have been repeated. The pits are deepening at the rate of 40 mils per year; the deepest observed was 160 mils.

Decontamination. An aqueous solution of 0.75 M NH_4OH, 0.5 M N_2H_4, and 0.25 M EDTA $(Na)_4$ (KAPL-HV) was tested as a single step decontaminant for stainless steel systems. Decontamination factors of 3 to 8 were obtained on samples from PRTR jumpers after 17 hours of exposure at 95-98 C in beakers. Additional decontamination, with over-all DF's up to 14, was obtained after another 24-hour exposure to fresh solution. These DF's are comparable to those obtained with other decontaminants; this solution warrants further evaluation.

Reactor Components Development

Fretting Corrosion Investigation. The vibration monitor transducers and electronics were calibrated during the last reactor outage. It was found that the transducers were completely serviceable after

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being in the radiation environment of the PRTR lower access area and that the maximum deviation from their original calibration was 6%. The units were reinstalled in the same tube, location, and attitude as during the previous operation.

The reactor startup of June 15 and consequent operation at 70 Mw produced an increase in inlet jumper vibratory motion of two (1653 and 1354) of the three tubes monitored. The other tube, 1449, is responding very nearly as it did during the April operating period.

Typical values for the two periods are as follows:

	Tube 1354		Tube 1653	
	April	Present	April	Present
Nominal peak-to-peak amplitude, mils	3.0	6.6	4.0	6.5
± Oscillation, mils	0.1	0.8	0.1	0.5

The primary pump and fuel element-pressure tube combinations were the same in both periods. Other reactor parameters, such as pressures, temperatures, and flows of the primary, moderator, and secondary systems, are virtually the same. Thus, it is felt that variations observed in the vibration levels are not directly attributable to the more obvious operating parameters. It is postulated that vibration amplitudes result from a complex combination of two factors; one, a basic vibration level which is characteristic of principal reactor parameters, and, two, a varying and metastable magnitude which results from sources presently undetermined.

A water sample taken June 16 analyzed at 1.7 ppb in zirconium content. This reading is considered above normal (which has been defined as < 1 ppb) and presumably is indicative of fretting corrosion but may be due to the prior charge-discharge operations. Additional samples have been taken but are not yet analyzed.

A test was performed at 70 Mw operation which increased the inlet and outlet primary bulk temperatures approximately 20 degrees from normal. The maximum peak-to-peak amplitude of vibration on 1653 increased 2.2 mils. This condition is being investigated in detail.

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2. Plutonium Ceramic Fuels Research

Radiographic Image Intensification. Initial application of an Image Orthicon (image intensification) TV system to x-ray and gamma ray radiography indicates system resolution and sensitivity, with dynamic response which equals or exceeds that of conventional time exposure radiographic techniques. Readout phosphors and optical coupling to the TV system will be optimized before a quantitative comparison is made.

Plutonium Ceramics Irradiation. Specimens of PuN-Pu cermet and PuN-W cermet were discharged from the MTR after approximately 20×10^{20} fissions/cm^3 exposure. These capsules will be returned to Hanford for post-irradiation examination.

The second capsule of UN-20 wt% PuN (GEH-14-617) was discharged from the MTR. The approximate burnup on this specimen is 5×10^{20} fissions/cm^3 (~18,000 Mwd/ton). The first capsule discharged (GEH-14-618) has a burnup of about 2.5×10^{20} fissions/cm^3 (~9,000 Mwd/ton); it is undergoing post-irradiation examination.

Beta Plutonium Sesquioxide. The preparation and properties of beta-Pu_2O_3 are being investigated. This compound can be formed by heating PuO_2 and carbon in vacuum and subsequently arc melting; however, small amounts of carbon remain. To prepare carbon free beta-Pu_2O_3, PuO_2 was heated to 1700 C for three hours in vacuum, heated to 1500 C in pure hydrogen, and arc melted, in sequence. The product was single phase and has an oxygen deficient, fluorite structure of composition $PuO_{1.71}$. This high O/Pu ratio is due to oxygen contamination of the arc melting atmosphere.

$PuO_{1.51}$, which gave a single phase beta-Pu_2O_3 pattern on the x-ray spectrometer, was prepared by heating $PuO_{1.8}$ with an excess of plutonium hydride in high vacuum for three hours at 1650 C. The product; many small, shiny, metallic appearing crystals; was subsequently heated to 1650 C in vacuum in a Ta crucible. No gross reaction occurred and the sintered product was easily separated from the crucible. The preliminary conclusion is that Ta and beta-Pu_2O_3 are compatible.

Pure beta-Pu_2O_3 prepared by arc melting a PuO_{2-x}-C mixture begins to oxidize at 200 C in air, with complete conversion to $PuO_{2.0}$ occurring below 400 C. This compound (beta-Pu_2O_3) is more stable than PuO_{2-x}, which is completely oxidized to $PuO_{2.0}$ at 200 C under similar conditions.

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The Plutonium-Boron System. Preliminary experiments indicate that, of the four known borides of plutonium (PuB, PuB_2, PuB_4, and PuB_6), only the diboride is thermodynamically stable below 900 C.

PuO_2-SiO_2. A plutonia-rich glass was prepared by arc melting SiO_2 chips and a PuO_2 pellet under one atmosphere of argon. Preliminary x-ray diffraction and ceramographic examinations reveal little solid solubility between PuO_2 and SiO_2. Photomicrographs show what is probably an eutectic and a third phase tentatively identified by x-ray diffraction as $PuSiO_4$.

Clad Plutonium Cermets. The following high density cermet discs (0.6-inch diameter) were prepared by pneumatic impaction.

Beta-Pu_2O_3-50 vol% W	(tungsten clad)
PuN-50 vol% W	(tungsten clad)
PuO_2-62 wt% (80 Ni/20 Cr)	(80 Ni/20 Cr clad).

3. Ceramic (Uranium) Fuels Research

Fission Products in Metallic Uranium Inclusions in Irradiated UO_2. Preliminary radiochemical analyses show concentration of Cs and Sr in metallic uranium formed during high temperature irradiation of UO_2. The uranium inclusions were selectively leached with HCl, and radiochemical analyses showed 1000 times more Cs-137 and ten times more Sr-90 in the leach solution than in the UO_2. No selective concentration of Ru-106 in the metallic inclusions was observed.

Irradiation of Uranium Monosulfide. A small, 0.25-inch diameter cylinder of sintered uranium monosulfide, irradiated to $\sim 3.3 \times 10^{20}$ fissions/cm^3 at < 600 C, released 3.8% of the fission gas formed.

Irradiation of Uranium Nitride. Two uranium nitride capsules were irradiated at calculated rod powers of 646 w/cm (19.7 kw/ft) and 1150 w/cm (35 kw/ft) to 0.18×10^{20} and 0.32×10^{20} fission/cc, respectively. No sintering of the UN occurred during irradiation. Fission gas release was less than 2%.

Induction Heating of UO_2. UO_2 pellets were melted by direct induction heating in a dried argon 8% H_2 atmosphere. Subsequent ceramographic examination of the pellet cross section revealed only single phase, nearly stoichiometric oxide. Earlier experiments revealed that UO_{2+x} was produced in the center of samples induction melted in oxygen contaminated argon.

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BeO-PuO_2 Studies. Three small cans of a BeO-PuO_2 mixture were impacted. The nickel coating on PuO_2 particles apparently remained intact, and no unusual neutron activity was evident during or after the compaction.

Metal Clad Cermets. Uniform, adherent deposits of vapor plated tungsten were applied to tungsten-UO_2 cermets by transfer of the tungsten from molybdenum substrates during pneumatic impaction.

UO_2-PuO_2 Homogeneity Studies. Autoradiographs of impacted, ball-milled UO_2-20 wt% PuO_2 powders and of sintered $(U_{0.8}Pu_{0.2})O_2$ made via coprecipitation from solution show visibly identical plutonium distribution. Mixed fuel powders were dry ball-milled 64 hours to obtain a median particle size of 2.7 microns (96% of the particles less than 10 microns) before impaction. The alpha particle autoradiographic technique was refined by using thinner (25μ, 5μ, 2μ) and more sensitive emulsions to improve resolution. With 2 micron thick emulsions, the alpha tracks are infrequently seen and only dots register the sources of alpha activity. Filters used to reduce track and dot density facilitate quantitative analysis of plutonium distribution. The improved resolution obtained with the 2 micron emulsion reveals what may be an ordering (lack of randomness) of the alpha particle sources related to grain boundary segregation.

The effect of ball-milling time on particle size and plutonium distribution is currently being evaluated.

High Temperature Dilatometry. The high temperature dilatometer was calibrated against tungsten to 1600 C. The upper temperature limit of the polycrystalline alumina sample holder is 1600 C. Above this temperature, sample holder deformation became the limiting factor. The lower limit of temperature was established as 300 C. Below this temperature, heating rate control and thermal gradients across the sample holder resulted in nonreproducible data. A thermal expansion curve for single crystal UO_2 between 300 C and 1600 C was measured. Glove box installation for the apparatus is under way.

Electrical Resistivity of Molten UO_2. Electrical resistivity data were obtained for UO_2 at high temperatures (near or above its melting point of 2800 C) and pressures (approx. 70 atmospheres). The values are higher than expected from extrapolation of low temperature data but correspond well with the electrical conductivity that would be required to explain the apparent high thermal conductivity of UO_2 near the melting point.

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Melting Points of Sm_2O_3 and Nd_2O_3. The melting points of Sm_2O_3 and Nd_2O_3 in purified argon and 8% H_2-argon, redetermined with increased precision, were 2250 ± 50 C and 2260 ± 30 C, respectively.

4. Basic Swelling Studies

Irradiation Program

Uranium wafers, 0.2 mm in thickness by 3.0 mm in diameter, were sealed in an aluminum capsule and the capsule sent to the reactor for charging. After irradiation, the wafers will be thinned electrolytically for transmission electron microscopy in order to directly view fission event induced defects.

The general swelling capsule containing enriched uranium specimens, to which stainless steel pellets were added to improve the heat transfer characteristics, was successfully irradiated at a controlled temperature of 400 C (752 F). The successful modification of the thermal characteristics of the capsule provided information that can be used for attaining greater versatility in the thermal design of future capsules.

The prototype high pressure irradiation capsule has been processed through ex-reactor tests. It was operated at a maximum temperature of 750 C (1382 F) and a maximum pressure of 157 kg/cm^2 (2250 psi) at 525 C (977 F). The extension of the NaK expansion bellows was recorded under all operating conditions. The NaK volume change data, in conjunction with the thermal data, indicated that the performance of the capsule satisfied all design requirements. As a result, the first high pressure capsule for in-reactor test is currently being constructed in accordance with this design.

Post-irradiation Examination

Two uranium specimens that had been irradiated at 525 C (977 F) to 0.03 at% B.U., and 575 C (1067 F) to 0.10 at% B.U., respectively, were heated in vacuum into the beta phase (approx. 750 C or 1382 F) for 15 minutes. Both specimens had been previously post-irradiation annealed at 625 C (1157 F) for 100 hours during which coalescence of crystallographically aligned porosity and an increase in density had occurred. After the present anneal into the beta, no significant change in density was observed. Preliminary metallographic evidence, however, indicated that the major portion of the porosity is now located at the boundaries of the alpha grains which existed just prior to the beta anneal. Two other specimens irradiated similar to

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those which were beta annealed are currently being annealed at 625 C (1157 F) for 1000 hours.

Restrained Irradiations

Zircaloy-2 clad rods of uranium and U-2 wt% Zr alloy are being irradiated in NaK-filled capsules to provide information on fuel performance under various conditions of cladding restraint.

Density measurements have been completed on 22 declad samples that operated at volume average uranium temperatures, ranging from 400 to 655 C (752 to 1212 F) for unalloyed fuel and from 475 to 630 C (887 to 1166 F) for U-2 wt% Zr. Burnup of these samples as determined from chemical analysis fell into two general ranges--0.16 to 0.22 at% and 0.3 to 0.32 at%. Although there is considerable scatter in the density changes, some qualitative conclusions can be made from the data.

In several alloyed and unalloyed samples with 0.025-inch thick cladding severe grain boundary tearing and porosity other than fission gas porosity was observed. This structural damage is reflected by large density decreases. No such effect was seen in the samples with the thicker cladding. The restraint offered then by the 0.035-inch thick cladding would appear sufficient to suppress, or at least reduce, the grain boundary tearing.

Second-Phase Distribution in Dilute Alloys of Uranium

Document HW-80349, which presents the results to date on the quantitative metallography of second-phase particles in dilute uranium alloys, has been prepared for publication. Information included in this document was presented at the 18th Meeting of the AEC Metallography Group on June 22-24, 1964, at Atomics International. The three methods used to calculate the particle size distributions of the precipitate particles showed general agreement in the shape of the distributions, with certain exceptions, which were readily explained on the basis of the characteristic features of the particular method involved. The initial experimental data showed that these dilute alloys behaved in accordance with the established theories of solid state precipitation reactions, although considerable work needs to be done in order to determine optimum thermal treatments to obtain the most desirable distribution of the precipitated phase.

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5. Irradiation Damage to Reactor Metals

Alloy Selection

Several nickel base alloys are being studied to determine the effects of irradiation and environment upon the mechanical properties. These alloys are being irradiated at 280, 580, and 740 C (536, 1076, and 1364 F) and tested at room temperature and at 700 C (1292 F). Room temperature tests on Inconel 625, Inconel 718, Hastelloy C, Hastelloy N, Hastelloy R-235, and Hastelloy X-280 show a marked effect of irradiation temperature. Ductility and strength values of these alloys remain good at the 280 C and 580 C irradiation temperatures. However, it is generally observed that specimens irradiated at 740 C show a large loss in both strength and ductility.

Tensile specimens of W, W-25 Re, Ta, Ta-10 W, Mo, and TZM are being irradiated to determine changes in the ductile brittle transition temperature. Three capsules containing these alloys were sent to the ETR for irradiation to a goal exposure of 1×10^{20} nvt. Control tests were started this month to determine the pre-irradiation values of the tensile transition temperature.

In-reactor Measurement of Mechanical Properties

An in-reactor creep capsule containing an annealed 304 SS specimen has been charged in the reactor and will be brought to test conditions of 20,000 psi creep stress and 600 C (1112 F). A test under way at 20,000 psi and 500 C (932 F) for the same alloy shows a creep rate below the minimum resolvable rate of 2.5×10^{-7}/hr after 1200 hours of testing. During an outage which occurred in the course of this test, an indication of an increase in rate was observed. A longer outage will be required to determine whether the observed increase was significant. An in-reactor test of 304 SS at 550 C (1022 F) and 20,000 psi was terminated after 600 hours. The rate at this time was 1.1×10^{-6}/hr.

A test at 500 C (932 F) - 30,000 psi has not accumulated enough time to determine a creep rate. Ex-reactor and in-reactor creep rates in all cases appear to be similar for the annealed 304 SS.

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

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determination of mechanical property changes produced in metals by irradiation at elevated temperatures.

During May 1964, the 50% reduction in total elongation for Inconel X-750 specimens, heat-treated in helium-filled quartz ampules as compared with those treated in air, was reported. The treatments were as follows: (1) in helium-filled quartz ampules, 2150 F (1177 C)/2 hrs, AC; 1550 F (843 C)/24 hrs, AC; 1300 F (704 C)/20 hrs, AC; (2) in air, 2100 F (1149 C)/1/2 hr, RAC; 1550 F (843 C)/24 hrs, RAC; 1300 F (704 C)/20 hrs, RAC. The differences between these treatments were: (a) environment: helium versus air; (b) cooling rate: slow cooling of specimens enclosed in quartz ampule versus rapid air cooling of specimen in air circulated by a fan; and (c) solution-treatments: 2150 F (1177 C)/2 hrs, versus 2100 F (1149 C)/1/2 hr.

Metallographic examination shows a significant difference in the amount and blocky character of the carbide phase in the grain boundaries. The carbide phase is less abundant for the more rapidly cooled air-treated specimen. Metallographic examination has also shown finer grains for those specimens treated in air due to the lower temperature and shorter duration of the solution treatment used. Both of these factors--lesser carbide phase and finer grains--could have resulted in the difference in elongation that was found. Test treatments will be made to separate the effects of cooling rate and solution treatment on ductility.

Damage Mechanisms

The objective of this effort is to determine the mechanism by which defects produced by neutron bombardment interact with dislocations in the metal to modify the plastic deformation characteristics of the metal. The investigation is currently concerned with the role of interstitial impurities in alpha iron.

Further results from computer analysis of stress relaxation curves have provided insight into the processes of thermally activated flow. All curves analyzed to date have agreed well with the theoretical expression $\dot{\varepsilon} = \dot{\varepsilon}_o (T^*/T_{max})^n$. Here $\dot{\varepsilon}$ is the observed strain rate, T^* is the effective stress, and $\dot{\varepsilon}_o$ and T_{max} are material constants. The strain rate sensitivity coefficient, n, is found to increase with decreasing temperature for both Ferrovac "E" and zone-refined iron. The coefficient is lower, however, for the zone-refined iron.

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Another experiment in which a series of stress relaxation curves were run on Ferrovac "E" iron at increasing strains showed a correlation with the electron transmission microscopy work of Keh and Weismann. The values of T* decreased to a constant value at about 3.5% strain and remained constant up to the ultimate load point. Keh and Weismann observed that a stable cell structure had been produced in similar iron specimens by about this same amount of strain.

Brittle fracture of the zone-refined iron at liquid nitrogen temperature has been shown to be intergranular in nature. Various heat treatments to prevent segregation at the grain boundaries are under study.

Oxidation of Refractory Metals

Corrosion of molybdenum and TZM molybdenum alloy in 1000 C (1832 F) oxygen is highly pressure sensitive in the range 5×10^{-4} - 5×10^{-3} mm Hg. A descaling process developed for nickel base alloys successfully strips oxide from the molybdenum samples.

ATR Gas Loop Studies

Progress of Model Loop Construction. On June 1, 1964, a second welder--qualified to the ASME Code--was added to the plant maintenance crew working on loop construction. This addition to the work force speeded up construction significantly. As of June 18, 1964, construction of the model high temperature gas loop was 80% complete. Early in July, the gas bearing compressor will be used to circulate air, at standard temperature and pressure, in the loop for the initial phase of loop startup.

Helium Purification System. The helium purification system manufactured by Engelhard Industries was delivered. The liquid nitrogen storage tank was installed.

Gas Analysis. An absorption column for the gas chromatograph packed with Linde 12X molecular sieve has produced absorption peaks of improved sharpness. Three gas standards were prepared and extrapolation of peak heights indicates a lower detection limit of less than 1 ppm for O_2, N_2, H_2, CO, CO_2, and CH_4 in helium. Quantitative calibrations have been completed, and the instrument is in use for analytical work.

Gas Phase Corrosion. Haynes 25, a cobalt base superalloy, has been tested in a 100 Torr oxygen atmosphere and high vacuum at 2050 F (1120 C), the predicted maximum operating temperature of the ATR

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loop structural materials. In 100 Torr oxygen, decreasing the temperature from 2192 F (1200 C) to 2050 F (1120 C) results in a ten-fold penetration decrease in 500 minutes' time. The high vacuum test showed a three-fold decrease in penetration (due to evaporation) when the temperature was lowered from 2192 F to 2050 F.

Radiation Damage Exposure Unit. An exposure unit that has been suggested to account for the effect of differences in neutron spectra (HW-SA-3332) on radiation induced effects has now been applied to a body of experimental data in which all experimental variables except the neutron spectrum were held constant.* Charpy V samples of A-212B steel were irradiated in two positions in the Low Intensity Test Reactor (LITR), and in one position in the Brookhaven Graphite Reactor (BGR). Impact tests were made after irradiation to measure the shift in nil ductility temperature (ΔNDT).

Exposures were originally calculated for neutrons with energy greater than 1 Mev on the basis of an assumed fission spectrum in each position. This conventional method of reducing data, without consideration for differences in neutron spectrum indicated that a difference of nearly a factor of two existed for the property change of samples irradiated to the same exposure in the two reactors. Exposures to neutrons with energies greater than 0.5 Mev were calculated from the same activation data but with effective cross sections calculated for each irradiation position. The shift in nil ductility temperature on this exposure basis showed no difference for data obtained in the different reactors. An analysis of variance indicates that with greater than 95% confidence, the BGR data are not a separate body of data when exposure is expressed as E >0.5 Mev.

The exposure unit will be tested further to determine its general suitability for radiation damage studies. If the new exposure unit proves suitable, irradiation data can be applied in reactor design with reduced risk of failure or costly overdesign.

*L. E. Steele and J. R. Hawthorn. "Neutron Embrittlement of Reactor Pressure Vessel Steels" reported in "Materials and Fuels for High Temperature Nuclear Energy Applications" (M. T. Simnad and L. R. Zumwalt, Ed.), MIT Press, Cambridge, Mass., 1964.

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6. Gas-Cooled Reactor Studies

Thermal Oxidation of Large Graphite Samples by Water Vapor. A samples 0.426-inch in diameter and 2 inches long was machined from a graphite sample 1.5 inches in diameter and 12 inches long whose oxidation rates were previously reported (August 1963). The oxidation rate of this small sample was measured as a function of temperature using helium containing about 6000 ppm water vapor. In the temperature range 802 to 869 C, the following rate expression was obtained:

$$\text{Rate, hr}^{-1} = 1.24 \times 10^{7}\ e^{-59.9 \times 10^{3}/RT}.$$

Using this expression and the ratio of the effective-to-bulk diffusion coefficient for TSX graphite (2.43×10^{-3}) obtained by G. F. Hewitt of Harwell, the rate of oxidation of an infinitely long cylinder 1.5 inches in diameter was calculated at temperatures of 750, 800, and 850 C. These calculated rates compare well to those measured on the 1.5-inch diameter sample from which the small sample was machined.

Platinum as a High-Temperature Thermal-Diffusivity Standard. A reference material is needed to determine the accuracy of high-temperature thermal-diffusivity measurements of graphite and other materials. The thermal conductivity of platinum was measured by Slack [J. Appl. Phys., 35, 339 (1964)] and by Powell [Brit. J. Appl. Phys., 14, 662 (1963)]. Their measurements indicate that platinum may be a satisfactory material for a high-temperature standard. Thermal diffusivity was measured by the "flash" technique on two samples of 99.99% pure platinum over the range 25 to 500 C. The thermal conductivities calculated from the product of the thermal diffusivity, density, and specific heat were within 3% of the values reported by Slack. The measurements indicate that platinum is a suitable thermal-diffusivity standard at high temperatures.

Evaluation of the Burrell Model K-7 Gas Chromatograph. The Burrell Model K-7 gas chromatograph was evaluated for analysis of gas mixtures containing hydrogen, oxygen, nitrogen, methane, carbon monoxide, and carbon dioxide. This instrument has a thermionic detector (ionization detector with thermal emission of electrons as energy source) and is equipped with a gas sampling valve and dual columns.

Hydrogen, oxygen, nitrogen, methane, and carbon monoxide are adequately separated by an 8-ft long column containing 30/60 mesh molecular sieve 5A. At 75 C they are all eluted within 4 minutes.

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For carbon dioxide analysis, a 4-ft long column filled with 30/60 mesh silica gel is used at room temperature. The hydrogen, oxygen, nitrogen, methane, and carbon monoxide elute together after about 30 sec, followed by the carbon dioxide about two minutes later.

The detector is sensitive to all gases except helium, which is used as the carrier gas, and the limit of detection is about 1 or 2 ppm. The detector gives a signal which is known to be linear in the concentration range from 30 ppm to 1000 ppm, but this range may be much larger. At very low concentrations (~50 ppm) it is necessary to compare peak areas rather than heights because the peak shape is somewhat distorted.

7. Boronated-Graphite Studies

2-C Irradiation Tests. The 2C-2 capsule continues to operate satisfactorily. A slight elevation of temperatures in all sections has occurred during the irradiation period resulting in the two nominal 538 C (100 F) sections to operate at 543 C (1010 F), whereas at startup the temperatures were about 20 C lower.

Four auxiliary capsules containing 5 and 7%, grey and black material were irradiated in the Snout facility. These capsules were intended to supplement the 2C irradiations and to provide data at lower temperatures, all at an exposure of about 10^{19} nvt ($E > 0.18$ Mev). The capsules were designed for operation at 343 C (650 F), 232 C (450 F), 149 C (300 F), and 343 C (650 F), respectively. All capsules performed well and developed temperatures within 2 to 5 C of the goal temperatures.

With the exception of one capsule the samples have been measured and the data analyzed.

The tentative conclusions from these admittedly short exposure samples are as follows:

1. All samples of a given type and boron concentration showed an increasing tendency for expansion with decreasing temperature of exposure.

2. The transverse black samples showed the greatest expansion ranging from about 0.2% at 150 C to about 0.05% at 340 C.

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3. The dimensional change in the transverse grey samples and in all the longitudinal samples fell within a band ranging from about -0.01 to +0.07% for exposure at 150 C to -0.1 to -0.05% at 340 C.

4. The longitudinal grey samples showed the largest contractions.

5. Although the data are fragmentary, samples of 7% black and 7% grey material irradiated within boronated graphite sleeves showed contraction rates similar to those of the shield sleeves and to those of unshielded test samples. Although this requires verification, it implies that the n, alpha mechanism may be of lesser importance than originally thought and the fast neutron mechanism of greater importance.

Boronated-Graphite Studies. GEH-23-9, the replacement instrumented lead capsule for GEH-23-7 removed during mid-cycle 63 was charged into the ETR core during the cycle 64 shutdown early in June. The temperature data from this capsule will be used to estimate the temperature of the six capsules charged in the same general reactor location. Two of these capsules, GEH-23-3 and GEH-23-5, were discharged at estimated exposures of 6.0×10^{20} and 6.4×10^{20} nvt ($E > 0.18$ Mev), respectively. Each capsule contains three boronated-graphite samples.

8. Aluminum Corrosion and Alloy Development

The in-reactor corrosion test of aluminum-clad fuel elements in C-1 Loop at pH 4.5 and 260 C outlet temperature continued satisfactorily. The cladding temperature, as indicated by a thermocouple element, has risen more rapidly in the past month than previously. The cladding temperature no longer drops to its initial value after a reactor outage, indicating that the crud and oxide film is more resistant to spalling by thermal shock than during the first month of the test. This test will be discharged at the next outage.

9. Metallic Fuel Development

Irradiation Testing of Thorium-Uranium Fuel Elements. Three test elements of Th-2.5 wt% U-1.0 wt% Zr alloy fuel continue to show excellent irradiation performance in the ETR P-7 high-temperature, pressurized-water loop. The maximum exposure is currently 7400 Mwd/ton (0.85 at% BU). Fuel swelling based upon fuel element density measurements was 0.8 vol% at 0.85 at% burnup. During the last 4000 Mwd/ton exposure the maximum fuel temperature has been maintained at 530 C and the heat flux at 850,000 Btu/hr-ft^2.

10. USAEC/AECL Cooperative Program on Development of Heavy Water Moderated Power Reactors

Thermal Hydraulic Studies. Fabrication was continued of an electrically heated, 19-rod bundle fuel model for laboratory experiments investigating fog-cooled heat transfer conditions. This section will be 6.3 feet in length and will be used with special devices to control the distribution of the steam-water mixture at the entrance of the test section so as to improve the critical heat flux conditions.

Fabrication was also started on a heater to generate steam for use in the experiments. Water will be diverted from the flow loop through this heater, converted to 100% steam, and then mixed with water at the entrance of the test section to form the fog used in cooling the test section.

11. Conceptual Reactor Design Studies

Safety of Mixed PuO_2-UO_2 Fuels. To complete the present analyses of reactor kinetics problems associated with mixed oxide fuels, consideration was given to the fuel "slump" effect. Calculations indicate potentially large positive reactivity increments can result from collapse of the oxide within the cladding during an excursion in a fast reactor. To estimate the time from initiation of melting to the 100% theoretical density state, the model assumed is that of a viscous liquid falling from rest through a cylindrical tube.

Boiling H_2O Cooling of D_2O Moderated Reactors. A brief study was made on comparing the economics for boiling H_2O coolant to both liquid and boiling D_2O coolant.

Several fuel element designs and several lattice spacings were considered. It was concluded that D_2O cooling provides a saving of 0.1 to 0.2 mill/kwhr in fuel cycle costs compared to H_2O cooling. Analyses of the reactor plant, based on Document DP-830 and local experience, indicated substantial capital and operating savings for H_2O cooling compared to D_2O cooling. These savings are:

Reduced D_2O losses	0.1-0.2	mills/kwhr
Reduced D_2O inventory (including moderator)	0.3-0.4	"
Reduced capital cost	0.1-0.2	"

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When these savings of 0.5 to 0.8 mills/kwhr are reduced by the 0.1 to 0.2 mill/kwhr fuel cycle penalty, the net advantage of H_2O cooling (compared to D_2O cooling was estimated to be 0.4 to 0.6 mills/kwhr.

The major problem of H_2O cooling of D_2O-moderated reactors has been generally cited as "the positive coolant void coefficient." Fundamental principles make clear that the reactivity coefficient of the H_2O coolant may be made either positive or negative and may be controlled in absolute magnitude by regulating the relative and absolute quantities of D_2O-moderator and H_2O coolant and by the design characteristics of the fuel element and process tube. Exploratory calculations indicate that lattices sufficiently tight to achieve a negative coolant void coefficient are both technically and economically feasible. Certain variable lattice pitch design concepts may not only provide a negative coolant void coefficient but permit substantial further advantages in power flattening, reactivity control, and fuel management.

12. Critical Flow Studies

Experiments were started to investigate the critical flow behavior of two-phase steam-water mixtures from pipes with fittings at the discharge end. One of the first questions to be answered in this investigation was whether one of the more advanced critical flow models for straight pipe flow would also be applicable to a pipe with a fitting such as a tee or elbow at the end.

A test section was constructed consisting of a length of 1/2" schedule 40 pipe with a 1/2" schedule 40 elbow welded to the discharge end. This test section was installed in the experimental apparatus so that the elbow was wholly within a discharge receiver. By valving the exit line from the receiver, the back pressure exerted on the elbow could be regulated. In the preliminary test runs which have been made to date, only low pressure and quality flows have been considered. Stagnation enthalpies of 341, 290, and 252 Btu/lb and mass velocities of approximately 1300, 1600, and 2000 lb/sec-ft^2 have been considered. While holding enthalpy and flow rate constant, back pressure on the elbow was varied, and the effects of back pressure on the pressure distribution was noted. The results of these experiments showed that variations in the elbow back pressure were propagating up the test section at back pressures considerably below critical pressure predicted by the Fauske model. For example, for an enthalpy of 341 Btu/lb and a mass velocity of 1328 lb/sec-ft^2, the Fauske theory predicts a critical pressure of approximately 65 psia. In an experimental

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run with these flow conditions, variations in back pressure influenced pressures observed through the elbow and back into the straight pipe for a distance of several diameters for all back pressures above approximately 45 psia. These results suggest that the Fauske model might not provide accurate predictions of critical flow rates for elbows at the discharge end of a pipe in the range of outlet quantities investigated.

13. Upstream Boiling Burnout Studies

Additional boiling burnout data were obtained with an Inconel tube 0.444-inch ID by 0.819-inch OD by 60 inches long. Sixteen sheathed-type thermocouples were attached to the outside surface along the 24-inch electrically-heated portion of the tube. The tests were conducted at mass velocities of 1.0×10^6 and 1.5×10^6 lb/hr-ft^2 with a discharge pressure of 145 psia. Both upstream and downstream type burnouts resulted.

It was found that the mixing of the test section coolant stream with a cold quench water stream can greatly affect the test results. This mixing at the test section discharge apparently causes serious pressure fluctuations which are transmitted upstream into the heated region of the test section and affect the burnout conditions. Variations in the amount of quench water used not only changed the heat flux at burnout but also moved the burnout location from the downstream to upstream locations.

The variations in pressure fluctuations with quench water use are not readily discernible when only a Heise gauge is used to measured test section pressures. It was only when the test section pressures were monitored on a high speed recorder that the magnitude of the fluctuations became apparent.

14. Nuclear Rocket Fuel Studies

Thermal Cycling of Tungsten-UO_2 Cermets

Previous work indicated that the thermal cycling behavior of UO_2-W cermets is strongly influenced by impurities in the hydrogen gas atmosphere. Recent evidence suggests that surface oxide on the tungsten and/or UO_2 is equally important. To study this effect, hydrogen-purified tungsten and UO_2 were prepared, and several specimens were fabricated from these materials by high energy impaction (using a purified hydrogen atmosphere or vacuum for the entire fabrication process). Thermal cycling of these specimens, along with as-received and partially purified control samples, is in progress.

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Lower UO_2 losses during thermal cycling of a 20 vol% UO_2-W cermet fabricated by dry pressing and sintering suggests several additional procedures to be included with the high energy impaction process to reduce fuel loss. Of particular interest are stress relieving of the high energy compacts and subsequent sintering to improve grain bonding. In a continuation of this study, samples of 20 vol% UO_2 and W were dry pressed and sintered at 1750 C for six hours. These samples consisted of: (1) a duplication of earlier material, to substantiate previous cycling results, and (2) a cermet composed of as-received tungsten with new micronized UO_2 of a smaller ($<$ 5 microns) and more uniform grain size which might improve fuel retention.

Cermet Fuel Fabrication Development

Densities of 96.1 to 98.5% TD were obtained in a study of the effect of pressure and temperature on the density of tungsten and tungsten-UO_2 cermet fabricated by pneumatic impaction. Temperatures ranged from 1150 to 1250 C and impact pressures from 260,000 to 364,000 psi. One disc of tungsten and one disc of cermet were fabricated in each of nine impaction containers. Densities by water displacement of the cermet varied from 96.8 to 98.5% TD and of the tungsten from 96.1 to 98.1% TD. Results indicate more pressure than temperature effect. The discs will be sintered in hydrogen and checked again for density.

Two tungsten-UO_2 cermet and two tungsten 37-hole hexagonal honeycomb grids were fabricated by pneumatic impaction, hydrogen sintered, and sent to Lewis Research Center. Three 20 vol% UO_2-tungsten and three 40 vol% UO_2-tungsten cermet discs, 2 inches diameter and greater than 5/8 inch thick, were also fabricated by pneumatic impaction and sent to Lewis Research Center.

Impact bonding by pneumatic impaction followed by hydrogen sintering produced a metallurgical bond in the tungsten-to-tungsten-UO_2 joints of a 1/8 inch square honeycomb grid fabricated from NASA rolled plate. Sintering was done with the molybdenum mandrels still in place. The mandrels were removed with a solution of nitric and sulphuric acid. The two grids fabricated by this process were approximately 1/2 inch square and 1-3/4 inches in length.

Several 61-hexagonal-rod Cavitron drilling tools were fabricated. Induction heating was used to provide uniform heating and thus reduce the tendency to initiate thermal cracks in the tool. Silver brazing of the mild steel hexagonal rods prior to joining was discontinued when simultaneous brazing of tool and tool holder proved successful. Alignment of the tools during brazing was enhanced by using a tripod holder that is removed after brazing. Penetration of 20 vol% UO_2-tungsten cermet to approximately 1/2 inch has been reached thus far with the new tools.

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Fuel Element Design and Fabrication

A fuel element design concept based on the use of tungsten-UO_2 fuel plate stock is under study. This design consists of mechanically interlocked plates which form a grid on continuous "egg crate" having 1/8 inch square cells. Shop work was started on the fabrication of an unfueled tungsten model of this fuel element for testing at the Lewis Research Center.

The use of vapor deposition of tungsten on the mechanical "egg crate" assembly is being considered as a means of both bonding of the assembly and cladding of the plate edges if required.

Submicron UO_2 Dispersion in Tungsten

Four kilograms of coprecipitated mixed oxides containing 20 vol% UO_2 have been produced by the slurry technique as described in last month's report. This powder has been processed through the calcination step and is awaiting reduction.

A portion of the above powder was treated with wet hydrogen at 750 C until the tungsten trioxide had been converted to the dioxide. The dioxide was then further reduced in dry hydrogen at 1100 C until the dewpoint of the exit gas had stabilized at a -50 F or lower. Weight loss data indicate complete reduction; however, the powder exhibits a greenish tan coloration. The initial treatment with wet hydrogen was performed to provide a moist atmosphere to react with any residual nitrogen remaining in the mixed oxide after calcination. Nitrogen has been suspected as a contributing factor in the apparent discoloration of the reduced powders. Samples of the reduced powder plus samples at previously reduced powder using only dry hydrogen are being analyzed for nitrogen by a micro-Kjeldahl method.

A small batch of coprecipitated mixed oxide was ground and blended both prior to and after reduction to minimize the micro scale differences in grain growth and UO_2 agglomeration observed in previously compacted specimens. A compacted specimen of this material showed considerable improvement had been achieved in producing a more homogeneous material.

Extruded Tungsten Honeycomb Program

Three extrusions related to this program were attempted. One, a 0.730 inch diameter powdered tungsten compact canned in 2.125 inch diameter Mo, was preheated to 1700 C but stalled at two inches of extrusion length. The second, a co-compacted composite

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of seven Mo powder hexagonal rods in a tungsten powder cylinder canned in 2.125 Mo, was preheated to 1850 C and extruded to an eight-inch length before stalling. The third, the same geometry as the first except that the core material was coprecipitated, submicron W-10 wt% UO_2 compacted powder, was preheated to 1875 C and extruded completely to a length of 27 inches. All the extrusion ratios were 9:1. Severe chilling of this size billet at 60 in./min ram speed (max. speed of press) is responsible for the high preheat temperature that is required. The purpose of the extrusions was to determine the effect of as-compacted powder cores on the geometry and structure of the extrusion. Metallography of the last two extrusions is in progress.

Fueled Graphite Studies

Two time lapse movies have been taken of a small slice (0.2 mm x 1 mm x 8 mm) of a KIWI fuel element during heating in the reflection stage of the electron microscope.

One film shows four different particles in various stages of "break-through" at different times during a heating cycle which ultimately reached 2400 C.

In the other film the graphite matrix and an empty pyrocarbon shell was photographed. This movie indicates that the graphite matrix behaves the same on heating in the bulk as it does in the vicinity of the fueled particles.

Three improvements have been made in the experimental procedure which have practically eliminated the problems earlier encountered with microscope contamination and subsequent poor image quality and drifting. These are: (1) the use of a smaller sample requiring a smaller heat input to reach temperature ($\sim$50 watts to reach 2400 C versus 120 watts for earlier samples); (2) use of a more stable power supply with both current and voltage regulation to heat the sample; (3) an evaporated niobium coating a few hundred Angstrons thick on the entire sample.

The first two techniques served primarily to keep the sample and consequently the image stable, while the third drastically reduced carbon evaporation and thus kept the image quality from deteriorating. There was no noticeable carbon evaporation onto the viewing window after almost three hours above 2000 C; with no coating, the windows were opaque within a few minutes at about 1800 C.

Graphite welding has been attempted on the 600 KVA resistance welding machine. These efforts included exploration of tooling,

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joint design, and resistance welding parameters. This work has been done on short lengths of full size hexagonal sections of nonfueled graphite fuel element rods. The results of these exploratory efforts yielded several joints which showed evidence of bonding. The joints were brittle relative to the base material, and some cracks have been observed in the base material. This very limited effort has shown that the Sciaky resistance welder should be capable of graphite welding.

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.

Four capsules, each containing six rhenium foil samples annealed at 1300 C (2372 F) for 112 hours, have been prepared for irradiation. Pre-irradiation studies by electron microscopy and x-ray diffraction indicated that shorter annealing times were not effective in eliminating all cold work from the samples.

Preliminary contact has been made to arrange for stored energy release measurements to be performed offsite. Three samples of molybdenum, consisting of two irradiated specimens and one cold worked by swaging, have been packaged for shipment.

Growth of molybdenum single-crystal rods for program needs has continued. The growth technique employs two passes in the electron beam zone refiner followed by a third pass in which the crystal is "seeded" to obtain the desired orientation. The multiple pass technique produces crystals of uniformly high purity but is necessarily slow; crystals are grown at the rate of 10 to 12 per month.

The slip lines on the surface of bent single crystals of irradiated molybdenum are being studied. For crystals with a [110] longitudinal axis, and (001) and $(1\bar{1}0)$ faces, the slip system is (101) [111] when the bending moment is applied to the (001) face. Since the slip direction, [111], lies in the $(1\bar{1}0)$ face, the slip traces on this face are extremely fine. Slip traces on the (001) face are very coarse. In general, slip traces on unirradiated molybdenum crystals are finer and more evenly spaced than in irradiated

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crystals. Although individual slip lines within a band are not resolved in electron micrographs of the irradiated crystal, it has been established that slip occurs on several closely spaced planes rather than on a single plane comprising the band. Attempts are being made to correlate the slip lines with the channels observed by electron microscopy.

Molybdenum single crystals now being irradiated will be used for length-change, x-ray lattice parameter, and integrated diffracted intensity measurements. While awaiting discharge of these specimens, a number of diffraction experiments have been performed on unirradiated crystals of differing purity and annealing history. The Debye parameter, or Debye-Waller temperature factor, appears to be a fairly sensitive indicator of the extent of annealing in a particular crystal. The effects observed are due to a combination of thermal motion and static atomic displacements in the crystal. To separate the two effects, a series of measurements at different temperatures would be required. A simple cryostat for this purpose is being designed.

Strain rate cycling experiments on nickel foils have continued. Samples consisted of nickel which had been slow-cooled, quenched, quenched and aged at 225 C (437 F) for 10^5 seconds, and quenched and aged at 425 C (797 F) for 10^5 seconds. Strain rates were cycled from 0.01 to 0.1 cm/min, at temperatures of 297, 273, 196, and 77 K. Detailed interpretation of the results is in progress.

A report, "Quench-Hardening in Polycrystalline Nickel," HW-82708, has been prepared for publication as a formal technical report. A short communication, "Wafering of Bulk Specimens for Transmission Electron Microscopy," has been accepted for publication in the British Journal of Scientific Instruments.

2 Plutonium Physical Metallurgy

The objective of this program is to determine some of the basic physical metallurgical properties of high purity plutonium and to establish the effect of certain specific alloying additions on those properties.

The $\beta \rightarrow \alpha$ transformation kinetics of 0.005-inch thick wafers having a one-inch diameter were investigated at -196 C (-321 F). The incubation time was too short to be detected by the fluid displacement technique. The transformation was essentially complete after five seconds. Physical damage in the form of internal voids was essentially absent after 9 $\alpha \rightleftarrows \beta$ cycles.

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The steady-state creep rate of the beta phase was found to depend upon the prior transformation history. The creep rate of the beta phase formed by transformation from alpha was 200 to 400 times greater than that of beta formed by transformation from the gamma phase. In contrast to this, the steady-state creep rate of the gamma phase was the same after either $\alpha \rightarrow \beta \rightarrow \gamma$ or $\delta \rightarrow \gamma$ transformations.

Carbon replicas were obtained of fractured plutonium specimens that contained 100% beta and a mixture of 25% alpha and 75% beta. These replicas for electron microscopy are to be used to study the fracture characteristics of the beta and alpha phases, retained phases, and $\beta \rightarrow \alpha$ transformation characteristics.

Electrorefined alpha plutonium has been satisfactorily vacuum cathodically etched. The resulting microstructures were similar to the bright field microstructure obtained by electrolytic etching, using an alcohol-nitric acid solution. The grain boundaries and microscracks were sharply defined.

Further work on the texturing found in alpha plutonium which had been transformed from beta under an axial load has led to the conclusion that the $(20\bar{3})$ rather than the (020) plane was the most active in the transformation process. It is obvious now that the fiber texture of the columnar grained material and the deformation texture of the alpha-rolled plutonium will each require exhaustive investigations of several important lines in the diffraction pattern before the details of these textures can be intelligently discussed.

The first slab casting has been successfully made using a magnesium oxide crucible mold in the new vacuum induction furnace. A complete evaluation of the casting has not been made as yet, but from all external appearances it seems to be completely satisfactory. Rolling will start as soon as the evaluation is complete. This will represent the first attempt to roll the electrorefined LASL material which has been cast under optimum conditions into a suitable form for rolling.

E. CUSTOMER WORK

1. Radiometallurgy Laboratory

Examinations and Measurements

The results of routine examinations and measurements are, or will be, reported as part of the sponsoring research and development

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programs. During the period May 28 to June 28, 1964, Radiometallurgy Laboratory output included:

Metallography samples processed	74
Photomosaics	15
Autoradiographs	30
Replicas (for electron microscopy)	8
Burnup dissolutions	24
Fission gas sample collections	1
Vacuum induction furnace runs	9
Decladding dissolutions	15
Tensile tests	0
Rockwell hardness tests	2
Density determinations	27
X-ray analyses	6
Negatives processed	600

Equipment

Annealing Furnace. Manufacturer representatives were unable to calibrate the controller-programmer-recorder system, and the controller was returned for repair. Operating problems previously encountered during functional testing of the furnace appear to have been corrected by the factory.

Remote Impact Tester. A new quotation was obtained from Testing Machines Incorporated to inspect, modify, and calibrate the remote impact tester to meet Watertown Arsenal impact testing standards. The impact tester was removed from the cell, decontaminated, and packaged for shipment to TMI.

High Temperature Tensile Testing Machine. New, split insert-type, tensile testing grips, adapters, and extensometer clamps for both round and flat tensile speicmens were designed, fabricated, and tested at room temperature. Test results were satisfactory. The sub-base to support the tensile machine at the correct in-cell elevation was designed and installed. Piping and electrical hookup work are in progress.

"E" Cell Metallographic Facilities. Installation of remote controls on the metallograph continued. The metallograph manipulator and sample conveyor was installed. Modification of the ultrasonic cleaner was completed, and this unit with auxiliary sample washing and drying services was installed. Electrical and piping installation work continued.

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Stereo Zoom Cell Viewer. The stereo zoom viewer for macro viewing through the lead glass cell windows was received and tested. Results indicate that the new unit has greater light transmission than the older viewers with four magnification steps. Magnification range of the new viewer is 2.5X - 13.5X.

Remote Tweezers. Two remote tweezers were fabricated, and one unit was installed in "F" cell to improve the manipulation and handling of small samples and thin foil.

Electro Spark Drilling Machine. An order was placed for an electro spark drilling unit for evaluation. Possible applications include remote capsule opening and removal of small cores from metallic samples.

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 425 samples were processed, a total of 873 micrographs and macrographs taken, 2259 negatives printed, and 7462 prints processed.

A new 6 x 60-inch wet belt sander has been installed in the 306 Building laboratory. The sander is hooded and vented through a high efficiency cyclone particle separator to the 306 Building bag house.

Using the electron microscope, it is often possible to observe structural defects by electron transmission through foil specimens 100-2000 A thick. The same defects may not be apparent with the replica technique. Until recently, the Metallography Laboratory did not have the specialized equipment necessary to thin metals for this purpose. A commercial electropolisher, a Disa-Electropol, was purchased to fill this need. The equipment is now being modified for specimen thinning according to the procedure described in GERL 62-RL-(3186M).

3. High Temperature Lattice Test Reactor (HTLTR)

Placement of the brick in the large mockup and installation of the top cover were completed. Piping and electrical work is approximately 90% complete.

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Modifications to the horizontal control rod actuator assembly was completed. These modifications included alteration of the deceleration mechanism to include an inboard bearing and better fitting diaphragm mount and modification of the latch block carrier to allow more efficient operation. Numerous alignment problems were encountered during final assembly of the mechanism, all of which were subsequently resolved.

Assembly of the vertical safety rod has been completed, and the assembly, using a dummy element of carbon steel, has been operated successfully. Thirty-seven lift-and-drop cycles have been made with the assembly. High speed motion pictures were taken of three of the drop cycles. Initial analysis of these pictures indicates total insertion time of about 1.08 seconds. This includes about 0.15 seconds of system delay time before the rod starts to move. Redesign of the vertical safety rod has started to accommodate the wider (7-inch) rod that is now required.

Two potential problem areas associated with the insulating brick specified for use in the HTLTR are being investigated. The adsorbed water and gas contained in the insulating materials could be evolved during high temperature operation of the reactor leading to contamination of the reactor gas. Experimental work is under way to determine the requirements for outgassing of these materials and to assess their tendency to readsorb gases upon exposure to atmospheric air. The second potential problem area concerns the effect of the insulating brick material on graphite corrosion. A test is under way to determine the interaction of these materials in the reactor atmosphere at 1200 C.

4. EBWR Fuel Elements

Three hundred and twenty additional UO_2-1.5 PuO_2 EBWR fuel rods were delivered to Experimental Reactor Operations for approach-to-critical tests. Eleven hundred and twenty EBWR fuel rods have been fabricated to date, of which 550 will be retained at Hanford for further physics tests in the Plutonium Recycle Critical Facility. The complete plutonium-enriched core loading of 1296 fuel element rods plus 216 spare rods is expected to be delivered to Argonne on schedule with initial shipments starting in August.

A total of 199 internally scarred EBWR cladding tubes were internally honed. Of these, 132 successfully passed ultrasonic tests, and 67 remained defective. Approximately 25 tubes remain to be processed.

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A group of EBWR cladding tubes were received from ANL for ultrasonic examination at Hanford to further correlate the testing techniques used at the two sites. In addition, typical rejected tubes from Hanford will be shipped to ANL for further testing.

Five hundred kilograms of fused UO_2 initially rejected because of high gas and/or carbon content were purified by heat treatment at 1700 C for six hours in wet hydrogen.

A significant decrease in manpower required for UO_2-PuO_2 fuel particle preparation and an increase in fuel utilization were accomplished. For example, the crushing yield of vibrationally compactible UO_2-PuO_2 was increased from 73 to 91% (without recycling) by using a knife edge die fixture for opening Nupac cans. The knife edge creases the can lid, permitting less pressure to be used in opening the Nupac can and results in less pulverizing of the fuel.

5. Other Customer Work

Thoria Fuels. Thoria fuel element fabrication equipment was transferred to the Production Fuels Section, IPD, for the production of two additional tons of aluminum-clad thoria fuel elements. Assistance was provided as required to place the necessary processes and equipment in operation.

Phoenix Fuels. Approximately 3000, 1.960-inch diameter by 0.020-inch thick, Al-20 wt% Pu wafers were produced from plutonium containing 8 wt% Pu-240. Fabrication was accomplished by a novel spiral machining technique wherein wafers are cut from turnings machined from extruded Al-Pu cylinders. Fabrication of 6000 additional wafers with higher Pu-240 content is in progress.

The second Al-20 wt% Pu alloy, containing 16 wt% Pu-240, was prepared by reducing more than 2 kg of PuO_2 with aluminum in the presence of cryolite. The yields from the initial reductions was low (60%), but a yield of more than 90% was obtained from a subsequent reduction.

Irradiation Specimens for Phillips Petroleum Company. Irradiation specimens consisting of gold-aluminum and lithium-aluminum alloys are being fabricated by a coextrusion process. The extrusion of the gold alloys was completed, and final assembly work is in progress. The lithium alloys are being chemically analyzed prior to continuing fabrication.

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Containment Systems Experiment Capsules. Twelve stainless steel capsules containing sintered, natural UO_2 pellets were fabricated. The capsules will undergo short-term irradiations prior to testing in the Containment Systems Experiment. Simulated fuel capsules containing UO_2 doped with radioactive iodine will be fabricated by vibrational compaction at a later date.

Boiling Burnout Studies for the Advanced Test Reactor (ATR). The temperature and heat flux distributions for the ATR fuel elements were recalculated using the revised element dimensions provided by Phillips Petroleum Company. The results show that the heat flux on the edge of the coolant channel will be about 34% of the average heat flux for the coolant channel periphery. Similar calculations for the proposed test sections were made. The results show that a stainless steel edge on the flow channel results in edge fluxes of about 45% when the outer edge of the Cu-Ni coincides with the inside edge of the coolant channel or 32% when the outer edge of the Cu-Ni is 0.050-inch from the inside edge of the coolant channel. It appears that a spacing of 0.025-inch between Cu-Ni and inside channel edge would provide the desired heat flux distribution around the periphery of the coolant channel. New calculations with 0.025-inch spacing are being made.

A vacuum rolling method was tried for bonding the stainless steel and copper-nickel materials used in the test section. In the first attempt the assembly was mechanically but not fusion bonded. In the second attempt a higher temperature and greater rolling pressure were tried to improve the fusion bond. However, in this attempt, both the copper-nickel and stainless pieces bonded to the container walls (which had been oxidized to prevent this) but not to each other. Since this was not readily explained and a brazing method became available, the vacuum bonding technique was abandoned.

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PHYSICS AND INSTRUMENTS LABORATORY

MONTHLY REPORT

JUNE 1964

FISSIONABLE MATERIALS - 02 PROGRAM

REACTOR

N-Reactor Lattice Parameter and Spectral Measurements at Startup

In January, fuel elements containing detector pins of Pu-Al, U-235-Al, fuel enrichment uranium, depleted uranium, Lu, Eu, Au, and Cu both bare and cadmium covered were irradiated in N-Reactor at room temperature. In April a set of similarly instrumented fuel elements were irradiated in N-Reactor at an elevated temperature. The data from these irradiations are being analyzed to determine p, C_o, ϵ, the neutron temperature and the r-value of the epithermal flux.

Ratios of specific activities containing corrections for decay and for effective mass differences have been obtained for all the detector pins used in both irradiations. Data analysis of pin positions in the fuel for the January test is near completion while position measurements are in progress for the April irradiation. Correction factors for self-shielding are being sought for the respective detector materials, and an experiment has been performed in the PCTR to examine the self-shielding correlation between cylindrical and disk geometries for copper. Data analysis from this experiment is in progress.

Some difficulty was encountered in the determination of the appropriate Westcott g and s factors for each material. An IBM program GANDS is available for generating g and s values for various materials. Program GANDS assumes that the epithermal neutron spectrum is joined to the thermal neutron spectrum by a "sharp cutoff" function which for many materials is equivalent to Westcott's $\Delta 4$ joining function (CRRP-960). However, for materials such as Eu-151 with large resonances in the cutoff region, the g and s factors generated by GANDS will differ from those calculated by more exact methods.

Flux Ratios in TmO_2 vs. KVE Fuel

Relative 1/v flux ratios are desired for KVE fuel vs. two TmO_2 and graphite wafer mockups of heat sources. This will permit evaluation of the total activity induced in these mockup elements by irradiation in a production

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reactor.

The goals for the experiment have been set in discussion with IPD personnel, and several drawings have been submitted to the shop for construction. The remaining sketches are completed except for a few critical dimensions which must be supplied by an outside firm.

NPR Utilization Studies

Work on the physics of fuel cycle analysis for Phase III operation (power only), of the NPR has been started. Input data for the ZODIAC code is being collected, with particular emphasis on items necessary to evaluate the thorium cycle. This study is the outgrowth of a proposal, HW-81942, in which the fuel cycle costs of ThO_2, UO_2, Th, and U fertile systems are compared. The physics analysis will generate information on fuel enrichment (U-235) necessary to achieve exposures of up to 50,000 Mwd/t on a graded cycle, isotopic compositions vs. exposure, and temperature coefficients.

Instrumentation

Design and test efforts continued on a hybrid vacuum tube and transistor preamplifier scheduled for use with high capacity N Reactor fission counters. Modifications were continued on the main chassis pulse amplifier, discriminator, and calibration circuits. Continued engineering assistance is being rendered on N Reactor nuclear instrumentation.

Specifications were prepared for a control room recorder, one nuclear counting channel, replacement valves, and scintillation detectors for the experimental reactor fuels testing loop installed at PRTR. The specifications represent the final procurement for the system. To date, fully satisfactory operation has been achieved with the installed instrumentation.

Information regarding radiation shielding experimentation capabilities was provided for a study proposal and progress was achieved on the writing of a book chapter on radiation shielding for the IAEA.

System Studies

Computer runs on the N Reactor analog simulation were made to determine the maximum power level possible without draining the existing surge tank. The actual reactor controller settings from the reactor building were used for these computer runs.

Calculations of steam generator secondary water enthalpy and bypass valve flow rate were modified to give a more correct calculation. Also, the

emergency fill calculation was changed to more closely match the curve in the Bailey document.

Various types of computer runs were made to study different operating conditions. These runs included such conditions as: 70% power level with 10 dump condensers and eight heat exchangers, and 50% power level with eight dump condensers and eight heat exchangers. Computer runs at 125% power level were made to study the effectiveness of the large 25,000 gallon surge tank.

A request was received from NRD personnel to make runs on the primary loop flow with pump drop off. The program was patched and the runs completed.

Equation derivations for N Reactor simulation report appendix have been completed. The derivations investigated were primary pump-turbine model, injection pump-fluid coupling model, the secondary system emergency upstream fill valve, bypass valve, steam generator, density, and primary water volume contraction equations.

A revised nomenclature of the N Reactor simulation has been completed. This updating includes additions, correction, and description changes. The present list consists of approximately 470 cards. This list will be included in the N Reactor report which is in progress.

Measurements on the N Reactor (Test N2) disclosed the fact that a constant used in the analog simulation of the cold water injection incident was in error. Using the measured value of this constant, new computer runs were made as requested by the customer.

The electrical parts of the Ball 3X system of some of the existing reactors are to be redesigned. Using the present system as a standard, the proposed systems are to be analyzed as to reliability and the ability to handle special circumstances. Advantages and disadvantages of the system are to be expressed against the standard. The first effort will be directed towards collecting information needed and documenting it in a memorandum.

SEPARATIONS

Critical Experiments with Plutonium Solutions

A series of critical mass experiments were completed with $Pu(NO_3)_4$ solutions in a reflected sphere of 11.5-in. diameter (12.95 liter volume). The data obtained from these critical experiments have provided information on the criticality of Pu versus nitrate, the effect of water and concrete reflectors on criticality; and from neutron flux measurements, data were

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obtained for evaluating the critical bucklings of the Pu solution spheres.

Analyses of data from gold foil irradiations in the 11.5-in. water reflected sphere at a critical concentration of about 80 g Pu/ℓ have provided further information on the extrapolation length and material buckling of Pu solutions. In view of the paucity of these kind of data, the values are presented below, together with the results of previous measurements at a second Pu concentration for comparison.

Pu Concentration (g/ℓ)	Total Nitrate (g/ℓ)	H/Pu (Atomic Ratio)	Cadmium Ratio	Extrapolation Length (cm)	Material Buckling
83	110	310	2.0	5.55 ± 0.26	24,390 ± 440 x 10^{-6} cm^{-2}
254	340	44.6	1.2	6.08 ± 0.32	23,140 ± 720 x 10^{-6} cm^{-2}

The cadmium ratio was measured at the sphere center with five mil gold foils and 20 mil thick cadmium shields.

A series of experiments were begun with an unreflected 15.2-in. diameter sphere (30.2 liter volume). This unit permits extending the critical data on Pu solutions to unreflected systems, for which very few data currently exist. The 15.2-in. sphere is the first fully unreflected Pu solution assembly for which criticality has been achieved in the Plutonium Critical Mass Laboratory. Plutonium concentrations were in the range from about 40-80 g Pu/ℓ with the nitric acid molarities between 0.3-0.4. Neutron flux measurements were made with gold and lutetium foils for determining the buckling of the bare sphere and the effective neutron temperature of the system.

Pulsed Neutron Source Experiments

A new Norelco neutron generator and associated controls have been received. The new system provides 10^8 n/sec on continuous operation and up to 10^{10} n/sec under certain conditions of pulsing. The repetition rate can be varied from 60-3000 pulses/sec. The strength of this neutron source should permit reactivity measurements on subcritical systems without knowledge of the prompt neutron lifetime. Thus, the new unit is expected to be instrumental in the development and application of methods for making subcritical reactivity determinations on in-plant multiplying systems for nuclear safety.

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Miscellaneous Calculations for Nuclear Safety Applications

Further Monte Carlo and multigroup diffusion calculations have been made to evaluate the nuclear safety of a revised design for the HAPO-V shipping cask for slightly enriched irradiated fuel elements. The slightly revised design consists of four fuel canisters positioned in a square array on 24-in. centers. The amount of lead shielding which surrounds each 9-1/2-in. diameter cask varies between 9-in. to 15-in.; the central region of the shipping cask is void except for a sheet of boron steel midway between the canisters for neutron isolation.

In summary, the maximum k_{eff} for the cask should not exceed 0.9 as long as the fuel enrichment is less than 1.7%. This assumes that there is enough boron positioned halfway between the canisters to isolate one from another under flooded conditions. This also assumes that the situation would never exist where all the canisters are full or partially filled with water while the center section is void. If these two conditions cannot be assumed, the maximum enrichment permitted in order that $k_{eff} \leq 0.9$ is decreased to about 1.3%.

Critical Mass Laboratory Instrumentation

An analog computer study of the data obtained in pulsed neutron experiments is in progress at the Critical Mass Laboratory. The portable Applied Dynamics analog computer was connected to the analog readout of the multichannel analyzer. Equations for determining the subcriticality (effective reproduction factor) of a system using pulsed neutron theory were set up on the computer. Checkout of the system is now in progress.

Consulting Services on Nuclear Safety--Criticality Hazards

1. Nuclear Safety in HL

Comments were submitted to Waste Disposal and Decontamination Operation concerning safe limits for two new dry waste disposal tanks to be located in 300 Area. New nuclear safety specifications and changes in existing specifications were reviewed as follows:

a) The void date on Temporary Specification No. 3 was extended to 10-1-64.

b) B-6, Addendum 1, was issued to amplify safety requirements in critical approach measurements.

c) B-11 was issued to cover PuO_2-UO_2 fuel pieces.

d) K-1 was reissued in revised format; no limit changes were made.

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2. Nuclear Safety in NRD

Seventeen changes in the specifications (HW-80313) were reviewed. Most of these changes concern the handling and storing of 1.25 w/o U^{235} enriched uranium in the 333 Building.

3. Nuclear Safety Training and Education

Two persons are currently on temporary assignment for intensified nuclear safety training at the Critical Mass Laboratory. One is from CPD and the other from NRD.

A University of Washington graduate student who has been awarded a Richland Graduate Fellowship for summer, 1964, will perform thesis research for the degree of Master of Science in Nuclear Engineering at the Critical Mass Laboratory. The student was given the award for his proposed thesis research on a helium-3 neutron spectrometer.

Separations Instrumentation and System Studies

Measurements of the Pu-239 17 keV X-rays from two liquid samples, one of 2 g/l and the second of 10^{-3} g/l, were made with the mocked up collimated detector head for the Pu-239 liquid sample counting system. The detector head comprised an EMI-9536-B phototube and a 1 mm thick by 5 cm diameter NaI(Tl) crystal. Commercial solid state electronic instrumentation was utilized for the tests and satisfactory results were achieved. The obtained channeled counting rates were linear with a value of 3×10^4 counts/min per 1 g/l of the liquid solutions.

Simulation of the aluminum nitrate nanohydrate recovery process continued with the completion of 3000 iterative solutions of the simulated process. Fifteen and twenty vessel processes were assumed. Results have been passed on to the customer for his use in optimizing the process.

METALLURGY - Nondestructive Testing

N Fuel Testing

1. Fuel Element End Closure Testing

N Fuels Engineering has performed evaluation tests on the cap-to-core bonding test for the chevron end cap. Destructive analysis has verified the test results and has demonstrated good resolution for small unbonds. The test has been incorporated into existing equipment in the 333 production building, and is operating on a routine basis. The

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test technique, which uses a loss of signal, has been reported in TM-Memo 64-9.

2. X-Ray Fluorescence Test Development

PWR-109 was designed to determine the capability of NT-2 X-Ray Fluorescence Test. This test program has been completed and has demonstrated the test has the sensitivity and stability to test production at the required specification limit. The production capacity of one unit is estimated at 15 inner fuels per hour, or 8 outer fuels per hour.

The Radiation Counter Laboratory's transistor count rate units are on hand and one has been installed. A cost estimate has been made on production tester construction, and it indicated the need for evaluation of an isotope gamma source. An isotope source could possibly save money and improve performance.

3. Uranium Surface Contamination Testing

The production line alpha surface contamination testers had an availability of 100% during the past month. The service manual for the units is about 90% complete.

Work is in progress on the second generation alpha contamination counters. A special Lucite zinc sulphide test head was fabricated to enable measurement of contamination on cylindrical surface in a hole.

4. Irradiated Fuel Testing

All available irradiated NOT fuels (about 70) were tested during this reporting period. Only one fuel with definite flaws was found, and this particular fuel had been accidentally dropped ten feet in water which is believed to account for the core cracks present on both ends. Several other fuels had a high ultrasonic noise background. Part of this noise can be attributed to a rough inner surface (or adhering bubbles) as the angled ultrasonic beam used will reflect from surface mars. However, another part of this noise comes from within the core and may be attributed to small discontinuities. Destructive examination will be required to determine the nature of these discontinuities. A somewhat greater density of ultrasonic noise appeared at the ends of the fuels. Two fuels gave internal unbond indications which were subsequently determined to be caused by a series of closely spaced blisters. These two fuels were located approximately in the middle of a charge receiving high exposure. One of the fuels is being examined by Radiometallurgy.

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In addition to the NOT's, 24 NIT fuels were tested. Three of these had definite core cracks; none were known to have been dropped. It is significant to note that in each fuel the core flaws were at the ends, extending about 1/4 to 1/2 inch from the cap in a longitudinal direction. One of the three had cracks at both ends.

A rash of transducer failures preceded the testing of the NIT fuels, but none of the failures are attributed to radiation damage.

N Reactor Testing - Zircaloy Hydride Detection

The efforts of many investigators were reviewed and combined to produce a functional concept of the most effective eddy current hydride detection equipment believed possible with available technology. A prototype tester was designed, and is being built to check out this concept and to provide empirical data for construction of a tester to be sent to the reactor. Work on the design of the in-reactor probe has begun and is progressing satisfactorily.

Fabrication of the ultrasonic rotating probe for hydride detection is complete. The unit is being evaluated with several transducers, and a more complete checkout is in progress in the laboratory.

Construction of prototype fast pulse circuitry has been completed and the unit has performed satisfactorily during checkout. The design utilizes hybrid nuvistor-transistors circuits and will be used in the ultrasonic hydride test.

AlSi Fuel Testing

1. Irradiated Fuel Testing

Data taking for test evaluation was completed, and final evaluation must await destructive examination of four fuels selected from this group of ten. The four selected fuels include samples of three suspected types of flaws: (1) definite unbonds - all of which are thought to be smaller than the maximum allowable unbond in a bond tested pre-irradiated fuel, (2) flaws suspected of being either poor mechanical bonds or near core-clad interface cracking, and (3) core cracks.

2. Bond Test Development

The transducers received for evaluation have compared favorably to each other in detecting unbond areas on the I.D. of the AlSi fuel. Another

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order has been placed to determine the ability of the supplier to provide a uniform product. Experience in other areas of ultrasonic testing has shown that nonuniformity between transducers has contributed to a bias between testers.

The autoradiograph work has been completed on all samples and correlates well with the ultrasonic maps of the unbond regions. Ten representative fuels have been selected and will be used to assess the precision of the test using the MERCY program. The procedure for obtaining the data will duplicate as much as possible the conditions of production testing. Assessment of the precision of the test will be necessary to enable comparison with the existing internal bond test in the production facility.

3. Hot Die Sized Fuel Testing

All component parts of the manual for the Hot Die Sized fuel tester have been completed. The manual will be distributed as soon as the remaining sections are received from reproduction and assembled.

NEUTRON CROSS SECTION PROGRAM

Scattering Law Measurements for H_2O at 95°C

A series of measurements were made for three different values of neutron energy change on scattering. These measurements will replace data which were found to contain systematic errors due to "forbidden" Bragg reflections.

Time-of-Flight Spectroscopy for Slow Neutrons

The slow-neutron flux from the 4-B test-hole beam shutter at 105-KE was measured by gold foil activation. The measured intensity was consistent with the range of values calculated from the beam-opening geometry and estimated neutron-source spatial distributions. This beam hole will provide the source for slow neutrons for time-of-flight spectroscopy of inelastic scattering. Further measurements were made of the crystal reflectivity for slow neutrons of some copper crystals. These measurements indicate that the reflectivity is comparable to that of one of the Be crystals now in use on the triple-axis spectrometer. A draft was prepared for a manuscript for journal publication on measurements of electronic time drift in BF_3- and He^3-filled proportional counters.

Fast-Neutron Cross Sections

The data from the measurements of MeV total cross sections made in May have been processed. These data were found to yield good cross section results for H^2, O, and N. The data for Br were internally inconsistent and a remeasurement of this cross section will be necessary. Debugging and modification of the computer program LILNED was continued. The basic function of averaging different measurements and analyzing their differences is now operating correctly. A magnetic tape of the MeV total cross sections compiled by Howerton at LRL was received and work is in progress to read the tape and compare results with Hanford measurements. A manuscript on the fine structure observed in the Hanford total cross section measurements was prepared and submitted for publication.

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Pu-Al - Light Water experiments in the PCTR

Calculations made with the "PHYSICS CHAIN" code indicate that polyethylene containing ~ 0.5 w/o boron will be needed for the U-Al experiment with $H/U\text{-}235 \cong 200 \frac{(\text{atom})}{(\text{atom})}$. The borated polyethylene disks shipped with the PPA should be adequate, since their range of boron concentration is ~ 0.2 to ~ 2.0 w/o. Chemical analysis of these disks is being performed as well as a determination of the size and distribution of the boron particles.

It should be possible to begin the experiment by mid-July. Aluminum fuel cans have been made and design of special graphite blocks to surround a hexagonal test core is essentially complete. Four 1/4" O.D. BF_3 tubes will be available within a few days. Other items to be finished include an aluminum spacer for the central test sample, foils and foil holders, cadmium covers for the BF_3 tubes, modifications to the flux traverse mechanisms.

PRTR Burnup Experiments

The inconsistency of the plutonium burnup data has been a major problem during the analyses of the experiment. One approach to the problem of reducing these inconsistent data has provided some interesting results. When the Pu-240 atom percent is plotted as a function of Pu-239 atom percent, all the data points lie within the error bars of the resulting curves. One curve results from the samples taken from the outer ring rods of the 19-rod fuel cluster, and the samples taken from the inner ring rods and the center rods define another curve.

If one then forms the ratio of the Cs-137 determination (d/m/ml) to the alpha determination (d/m/ml) and plots this ratio as a function of the Pu-239 atom percent, the consistency of the Cs-137 data and the alpha counting data can be evaluated. Of 81 samples on which these determinations were made, eight samples plotted outside the error bars of the resulting curve. The ratio was considered to be in error ± 4.25%. Since 12 samples of the above 81 samples were reruns, of the final 69 samples actually used, three plotted outside the error bars. The consistency of these data are, therefore, within the errors placed on the determinations.

These two steps include experimental data from two operations and constitute two-thirds of the total data. A remaining quarter of the total data includes sample weights, volumes, and sample positions. As a check on the consistency of this part of the data, the ratio of the Cs-137 determinations (d/m/ml) to the sample fuel density (gm/liter) as a function of Pu-239 atom percent was plotted. In this case 23 of the 81 samples plotted outside the expected errors, and includes 6 of the previously mentioned samples. Thus 17 samples appear to vary more than ±3% from the curve drawn through the data due to the lack of knowledge of the initial enrichment and poor solution preparation. The data are the most inconsistent and have not been used to calculate percent burnup of the plutonium.

Specific Power Increase in the PRTR

An analysis of the two-zone (UO_2 and Pu-Al) critical approach made during initial startup of the PRTR has been completed. The calculated value of the effective multiplication factor, k_{eff}, from HFN is $k_{eff} = 1.019$ or 1.9% high. The effect of the weir on the axial neutron leakage was not included in the calculation. This would improve the calculated result. Consequently, design calculations on the reduced core for the PRTR are continuing assuming the validity of this (GAM-1, THERMOS, HFN) calculational model.

Phoenix Fuel Program

1. Pu-Sm^{149} and Pu-U^{235} Systems

The plutonium-burnable poison system studies have been extended to include mixtures of SM^{149} and various Pu-composites. The reactivity-time behavior of these cores follows the expected patterns. Only the Sm^{149}, 95/5 Pu mixture shows a positive reactivity mismatch at an intermediate stage in the life cycle.

Additional calculations have also been performed on Pu-U^{235} systems. The 50/31 Pu is still too rich in Pu^{239}. The use of even more exposed

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Pu in conjunction with U^{235} may be of interest.

2. Zirconium Hydride Study

Plutonium-fueled ZrH cores may be of interest in connection with the Phoenix program. Cores of this type display interesting temperature coefficient characteristics.

The purpose of this study is to devise a computational scheme whereby prompt temperature coefficients in reactor systems containing zirconium hydride can be rapidly calculated. Several physical models have been developed for the treatment of neutron scattering in zirconium hydride, but extreme care must be taken in selecting the model suitable for a given situation. For example, the presence of both water and zirconium hydride in a core tends to produce severe discrepancies in the comparison of empirical and calculated temperature coefficients.

As a first approach, the Nelkin model, will be used in the KERNEL code to generate the zirconium hydride scattering kernel. This result will then be fed into SPECTRUM and GAM to generate temperature dependent group constants. Ultimately values of k_{eff} for various temperatures, and hence the temperature coefficients in various temperature ranges will be calculated for selected core configurations.

3. MTR Plutonium Loading Analysis

Time-0 statics calculations for the two loadings tested in August of 1958, MTR Cycle 108, have been completed. The two cores contained elements having an H to Pu atom ratio of about 500. The reactor physics core contained 3.69 kg of plutonium with 4.3 isotopic % Pu^{240}. The power core had about 0.25 kg less plutonium and the reflector was penetrated by a somewhat greater number of absorbing experimental pieces. Both cores, however, were surrounded by about 50 removable reflector pieces containing cooling water and capsules of materials to be irradiated. The cobalt in these capsules, alone, totaled nearly 30,000 grams.

The reactor physics configuration, based on measurable rod worths, had a "rods-out" multiplication of 1.200. A computed value of 1.192 has been obtained. The power configuration "rods-out" multiplication of 1.120 has been exactly duplicated. The incorporation of more exact physical detail in the reactor models will perturb these results by an estimated 0.5% $\Delta k/k$.

Code Development

1. HRG

A recently discovered error in HRG has been corrected. This error affected only the calculation of the group averaged microscopic transport cross sections for each nuclide, but made appreciable effect there. For example, results of a test case indicated that errors of as much as 50% in σ_{tr} could occur for some groups for some nuclides. In other work on HRG, output formats have been revised to make the results more readable. HRG will then be put on the Physics Chain tape.

2. GAM

A recently discovered error in the J-table on the GAM (and HRG) data tapes has been corrected. This table is used only when resonance integral calculations are made. The error, a factor of 10 in one entry, was present in the original data tape supplied by General Atomic. The effect of this error on previous calculations can only be conjectured. It would affect the contribution of any resonance with parameters lying in the immediate vicinity of the erroneous entry. The error was discovered when the parameters for the Pu^{240} 1 ev resonance landed in its vicinity; in this case the calculated total Pu^{240} resonance integral was low by 1/3. The J-table on the latest CLT's used on Physics Chain have been corrected, as have the tables on the latest HRG data tapes.

3. ZODIAC-2

In ZODIAC-2, CLERK B is replaced by CLERK C, and NORMAL MODES BY ALCHEMY. CLERK C accommodates twenty isotopes in any arrangement, as opposed to the fifteen isotope CLERK B, in which treatment of any specific isotope depends upon its location within the fifteen isotope array. Decay factors and captive multipliers are fixed within CLERK B, but are input to CLERK C. An additional advantage of ZODIAC-2 lies in the superiority of ALCHEMY over NORMAL MODES. ALCHEMY is able to reach a sound solution even with degenerate input of the sort that frequently arises when data are prepared in an automated manner as in the case with ZODIAC. ZODIAC-2 has satisfactorily duplicated previous results with the standard test case and has been released for use under programmer supervision. Preliminary input instructions were published and distributed to prospective users.

4. RBU - High Energy Inelastic Scattering

The inelastic spectrum tables in the RBU Basic Library have been updated to include newly calculated inelastic probabilities and the associated

excitation energy losses. The calculated probabilities are based on the statistical model of the nucleus and on a suitable weighting flux. An informal report which describes the calculation in detail has been written.

Isotopic Analysis of PRTR Samples

Isotopic analyses were provided on 8 plutonium samples of PRTR-irradiated fuel elements in support of the Plutonium Recycle Program. Of these, 7 were burnup samples from Al-Ni-Pu element Number 5109 and one was a recheck of a burnup sample from Al-Ni-Pu element Number 5095.

Instrumentation and System Studies

Developmental study continued regarding incorporation of improvements to the PRTR exhaust air monitoring system. New information was received indicating the desired sensitivity to be 3.5×10^{-10} μCi/cc for Cs-138, Rb-88, and I-131 radionuclides. This requirement dictates incorporation of a sampling system detector assembly. Conclusions reached during the study will be described in a report now being prepared.

During the month a preliminary test was conducted in anticipation of troubles that might be encountered in reading out moderator level and flux for forthcoming power spectrum analysis tests. It was found that a 1200 volt battery was a better power source than the standard high voltage supply that powers the uncompenated ion chamber because of reduced 60 cps noise. The Swartwout differential pressure transmitter worked well.

EDWR EXPERIMENT PROGRAM

Subcritical Experiments with EBWR Fuel

Experiments with the EBWR fuel elements in light water were completed in the Critical Approach Facility for the lattice spacings 0.93, 0.90, and 0.60 inches. An experiment had been conducted previously with the lattice spacing of 0.90 inches. In that experiment spurious results were obtained for the extrapolation length due to a faulty counter. The results for the three lattice spacings are listed in Table I. They are preliminary and changes may occur because of harmonic corrections.

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TABLE 1

Lattice Spacing (in)	Critical No. of Rods Experiment	Critical No. of Rods Calculated[b]	Extrapolation Length (cm)	Buckling ($x10^6$)
0.60	829	847 (-3 mk)	7.99	6513
0.90	452	474 (-6 mk)	6.75	6092
0.90[a]	456[a]	474 (-5 mk)	8.22	5538[a]
0.93	488	508 (-5 mk)	6.64	5521

(a) Earlier data.

(b) Physics Research Quarterly Report, January, February, March, 1964, HW-81659.

The number of rods for a critical loading are compared in Table 1 to values which have been obtained analytically using the Nelkin scattering model and the cross sections suggested by Sher. Also shown in the table is the difference between the calculated and measured multiplications.

Critical Experiments with EBWR Fuel

Substitution and worth measurements with the EBWR fuel in the H_2O moderated PRCF is continuing. A radial traverse of the reactivity effect of displacing H_2O with a fuel rod is completed from the center of the core to a radius 29% greater than the core radius. A vertical traverse along the center fuel rod position using an open ended cylindrical void 0.585 inches in diameter is completed. Several control rod materials and other reactor materials are being prepared for measurement.

The temperature coefficient was measured over a 5°C span from 20°C to ambient. This coefficient is approximately 0.025 mk/°C and is positive because the Lexan templates expand slightly more than H_2O as the temperature increases. The template expansion gives an effect which is opposite to what H_2O alone would give.

The reactor noise spectrum has been analyzed and the ratio of effective fraction of decay neutrons to the neutron lifetime is 75 ± 8 for the H_2O moderated PRCF.

Tests were continued on void producing materials for the PRCF. Reactivity effects $\Delta\rho$ of styrafoam was compared to H_2O and to Lucite and Lexan plastics in the PCTR. The $\Delta\rho$ (cents)/gram for H_2O, Lucite, styrofoam and Lexan are 0.0652, 0.0479, 0.0453 and 0.0344, respectively. When immersed in H_2O

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the void fraction of styrofoam samples changed 4 to 8% in 250 hours. Reactivity measurements are being made in the PRCF using the sample having the most stable void fraction. At the same time spectral index measurements are being made in the presence of and in the absence of the void.

The data obtained from copper and lutetium pins which were irradiated in the PRCF are being analyzed. The analysis of the copper data is completed and that of the lutetium data is approximately 50% completed. The copper radial traverse showed neutron flux distortion in the vicinity of a safety rod inserted to hold critical during the irradiation. In the region of the safety rod, the cadmium ratio for copper varied from 6 to 8. In the vertical direction, in the place of the removed central fuel element, the copper cadmium ratio was approximately 12.

Gold wires 0.020 x 50 inches were received and palladium foils 1/2 x 0.005 inches are expected within a week for further spectrum measurements. For these measurements stainless steel-gadolinium alloy covers for pin neutron detectors are being fabricated of several thicknesses. Two alloys are available, 300 series stainless steel with 20% gadolinium and Hastelloy with 0.5% gadolinium. An irradiation will be made in the PCTR to find an optimum cover thickness for each alloy and the degree of homogeneity of the alloy.

Calculations of Critical Approach Loadings

Calculations of the effect of neglecting the spatial weighting of the fast cross sections have been made for the EBWR fueled critical approach experiments. The results show a 0.2% (2 mk) maximum change in k_{eff} for all lattice spacings. Thus the homogeneous model for calculating fast constants for these systems proves adequate; this result agrees with similar studies for UO_2-light water systems. In addition, calculations utilizing HRG instead of GAM-1 for the higher energy cross sections were made which showed some slight improvement in the calculated critical mass (maximum error < 3%). The effects of including resonance spatial self-shielding calculations for Pu^{240}, U^{235}, and Pu^{239} in HRG were all slight (i.e., 1 mk at the most for the Pu^{240} calculation and nothing for the other two). The thermal parameters ($\bar{\eta}f$, $\bar{\eta}$ and f) as calculated using THERMOS were compared with those calculated using a monoenergetic, infinite medium energy model (P3-TEMPEST). The results tend to show that where there is agreement between $\bar{\eta}f$'s (and k_{eff}'s) the P3-TEMPEST method shows compensating errors in $\bar{\eta}$ and f.

EBWR Core Calculations

The effective multiplication for the cold-clean loading of the mixed oxide zone as well as the fully loaded reactor (i.e., including enriched and

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natural UO_2 + reflector) have been determined using a slightly different cell model than previously used (i.e., the model accounting for the hardness in the EBWR core). The effect of this model results in an increase in k_{eff} of 1% (1.085 to 1.095) for the mixed oxide zone and an increase of 1.5% (1.135 to 1.150) for the fully loaded reactor. The moderator temperature coefficient and the Doppler coefficient for the mixed oxide zone have been calculated and both are negative. The amount of boric acid needed to poison the mixed oxide zone, and the fully loaded reactor to cold-clean effective multiplications of 1.0 has also been determined.

HIGH TEMPERATURE REACTOR PHYSICS PROGRAM

The containment of thermal insulating materials within the gas envelope of the HTLTR is a design feature that may raise some materials problems. The area of major concern is the corrosion of reactor components by contaminant gases arising from incomplete purging of the graphite and insulating brick. Initial experimental tests have shown that the G32 brick to be used in the high temperature region can give off about 7×10^{-6} moles of gas per gram at 1000°C. The composition of the gas is 56% H_2O, 41% CO_2, and remainder N_2 and hydrocarbons. Diatomaceous earth gives off about 40 times as much gas as this, most of which is CO_2. Further tests have been started in which the amount of gas effluent will be measured during repeated heatings of the same sample. Similar measurements will be made with other insulating materials.

The Standard and C Exponential Piles were disassembled, the bars sorted by size and representative blocks measured to check machining tolerances in preparation for use in the HTLTR project. Enough highly satisfactory bars can be made available to fabricate the HTLTR stack. Keyway cutting and some length dimensioning will be required, but no further surface machining will be necessary.

NEUTRON FLUX MONITOR PROGRAM

A formal interim report outlining the status of the program to develop in-reactor methods of measuring neutron flux by the use of regenerating isotopes has been prepared and submitted for publication. The report includes estimates of uncertainties imposed by incomplete cross sectional data.

Plans to fabricate experimental regenerating detectors have proceeded with the procurement of sample quantities of U-234. This material was enriched to 10.2% with U-235 to provide the necessary regenerating material for use in the chambers. This is slightly greater than the 9.9% enrichment calculated as optimum using the MIN of INT computer program; however,

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results will not be significantly affected. Communications with the off-site fabricator indicate that some material deposition problems are being encountered. A testing and irradiation service request was completed and approved.

Fabrication of a new B-11 beta current neutron flux monitor assembly is progressing; however, delays are being encountered due to lack of delivery of the required cables. A partial shipment of cables was received; however, the resistances did not meet the specifications. It is believed the cables are usable for the planned tests wherein the assembly push rod was re-designed to decrease water velocity past the assembly to about 2.5 ft/sec. The decreased flow is expected to substantially reduce vibration problems encountered in previous tests.

Difficulties were encountered with water leakage in the aluminum can which held two waveguides and a He-3 gas plasma being employed to test the cross-coupling principle for the microwave neutron flux monitor. The leakage caused premature test stoppage with no useful test data obtained. Two new probe assemblies are being fabricated for further tests at the KW Reactor snout facility.

NONDESTRUCTIVE TESTING RESEARCH PROGRAM

Electromagnetic Testing

Characteristics of the multiparameter tubing tester are being developed to meet the requirements for eddy current inspection of N Reactor process tubes. One parameter of special interest is the detection of hydride in the Zircaloy-2 tubing. Initial tests using an internal eddy current coil in the multiparameter arrangement showed that signals from hydrided areas at the levels of interest were masked by test coil probe wobble signals.

To better assess the hydride detection problem, two sets of tests were made with small external test coils. In the first test a 1/8 inch diameter test coil, a 100 Kc oscillator, laboratory amplifier and a vector impedance locus plotter were used. With this arrangement, two hydride areas at high concentrations were readily detected; however, instrument noise masked signals from areas having lower concentrations.

The second test gave better results with a 1/4 inch diameter test coil and operated at 200 Kc. A signal-to-noise ratio of two was obtained in detecting a hydrided area having a concentration level of approximately 500 parts per million. Most of the noise was due to probe vibration during scanning and is expected to be reduced by use of an improved probe suspension. Stability tests on this equipment have not yet been made. The

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promising results obtained show that the hydride (conductivity) parameter can be included in a scanning type probe multiparameter test for N Reactor process tubes. These results also give encouragement to the efforts to detect hydrided areas at higher concentration with the large internal coaxial test coils for faster scanning.

A method of detecting end boundaries of aluminum inserts in a developmental tubular AlSi fuel extrusion was developed. An eddy current test was used to monitor the difference in electrical conductivity of the aluminum inserts and the surrounding AlSi. This test was performed using a 1/8 inch diameter test coil operated at 20 kilocycles. The finished length of the inserts was intended to be three inches with the insert sandwiched between two layers of AlSi each 0.020 inches thick. Although radiographic tests had failed to locate the aluminum inserts, this eddy current test accurately mapped out the irregular boundary of the inserts.

Fundamental Ultrasonic Studies

Longitudinal wave attenuation measurements on the aluminum, Zircaloy-2 and stainless steel samples are complete. Analysis of these results indicate that only two of the aluminum samples showed any differences in ultrasonic properties. The groups of three, of each material, were assumed to have different grain sizes and structure as the result of prior working and heat treatment. However, metallurgical examination of representative samples substantiated the ultrasonic results that the only significant grain size changes were in the aluminum samples. The stainless steel samples had very uniform grain structures as indicated by the nearly identical attenuation curves from the ultrasonic tests. One of the aluminum samples exhibited a sharp increase in attenuation at a frequency of three megacycles and remained relatively constant up to five megacycles. The attenuation of all other samples increased in the typical manner with frequency and no explanation for the behavior of the aluminum sample is evident.

Shear wave attenuation measurements have not yet been possible. Attempts to reduce pulse rise and decay times by damping the transducers with tungsten loaded epoxy backing members were not successful. The epoxy apparently continues to plasticize which makes uniform bonding to the transducer difficult. Also, the electrical connection to the backing member did not prove to be sufficiently adherent for repeated usage. Other methods for obtaining good damping characteristics for shear wave measurements are being explored.

A best effort contract was negotiated with an offsite vendor to supply glass samples having a variety of air filled cavities. It is anticipated

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that these samples will be suitable for wave diffraction studies on small imperfections. Inquiries were made to determine recommended procedures for vacuum diffusion bonding of metal samples as a possible alternate method for fabricating small imperfections in metals. The suggested parameters of pressure, etc., are compatible with onsite equipment and initial diffusion bonding experiments are under way.

Heat Transfer Testing

An experiment using a flash lamp as a heat source showed that the differences in thermal diffusivity between aluminum, quartz and Lucite could be demonstrated. To eliminate emissivity effects in the pulse method, a thermal transducer of a thin sheet of black paper was inserted between the flash lamp source and the sample surface. Heat transfer from the transducer to the sample was due to thermal conduction through the thin layer of air between the two. Since the thermal conductivity of air is almost independent of pressure near one atmosphere, heat conduction to the sample should be constant for a given transducer--sample spacing and temperature difference.

Fatigue and Residual Stress Detection

Bar samples of 304L and 4340 stainless steel and 212B carbon steel were flexed in four-point bending at 1800 cycles per minute to within about 85 percent of their fatigue life. The fatigue condition of the bars was determined by monitoring the sample temperature and noting its rapid increase as fatigue failure approached.

Ultrasonic critical angle tests were conducted on the prepared samples to evaluate fatigue detection capabilities. Comparisons with the unfatigued samples showed beam shift signal changes as much as a factor of ten. Some samples had small fatigue cracks which were easily detectable when the critical angle test was used as a pulse-echo test. The pulse-echo method was used primarily to find positions on the fatigue samples which were free of cracks. The beam shift changes were then measured on portions of the fatigued specimens which had pulse-echo background signals about equal to those on the unfatigued samples. From this preliminary work, it appears that fatigue can be detected before the surface cracks initiate.

It was interesting to observe that differences in beam shift signals were detected in some of the supposedly identical samples prior to their being fatigued. Although it was not determined whether there would be any correlation with fatigue life, the possibility for precharacterization of metals by critical angle tests is intriguing.

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Fatigued areas on a 304L stainless steel sample were detected using an eddy current method. Areas containing cracks located with the ultrasonic tests also gave large eddy current indications. Further eddy current tests using improved circuitry and coil design are being planned.

A search of the literature revealed that stress can influence the thermal properties of solids. Thus, the thermal transducer technique being developed should be applicable to the detection of residual stress, provided the necessary sensitivity can be attained.

Detection and Imaging of Ultrasonic Energy

The study of wavefront reconstruction as a method of imaging ultrasound was continued. Two beams of ultrasound were positioned to interfere at a water surface. The resulting interference pattern was observed with a specially constructed optical system. Four diffraction orders were observed on either side of the undiffracted zero order image. The ability to produce well separated diffraction orders is essential to the wavefront reconstruction imaging technique described in HWIR-1731. Diffraction orders were observed only with pulsed ultrasonic beams. Continuous beams resulted in water surface distortion which either obscured or prevented the formation of diffraction orders. It is believed that continuous waves will also produce diffraction orders if multiple reflections of ultrasound are prevented. The diffracted light beams were shown to be due entirely to interference between the ultrasonic beams. When either of the ultrasonic beams were shut off, no diffraction orders were observed.

Nondestructive Testing for Isotope Containment Cells

The thermal diffusivity of compacted $SrTiO_3$ in a cross-sectioned isotope containment cell was measured using a thermal transducer technique. Although the transducer has only been developed enough to distinguish gross differences, the $SrTiO_3$ appeared to have a thermal diffusivity similar to that of quartz. The thermal diffusivity of single $SrTiO_3$ crystals is given as 0.021 cm^2/sec in the literature. Thermal properties of the compacted powder would be somewhat different, depending on the fraction of theoretical density attained.

USAEC/AECL COOPERATIVE PROGRAM

Nondestructive Testing of Sheath Tubing

Use of the prototype sheath tubing tester to test a variety of tubing types continued. The tester was set up to test seven foot lengths of 5/8 inch diameter - 50 mil wall Inconel tubes to be used in a heat exchanger. The noise level in this tubing was equivalent to a 1.5 mil deep notch; consequently, the tubing could not be tested for notches at the usual low level

of 1 mil. Grain size measurements revealed grains as large as 1.5 mils which corresponded to the ultrasonic noise level measurement.

The tester was subsequently set up to detect 2 mil deep by 15 mil long circumferential and axial notches on both the inside and outside surfaces. The ultrasonic entry angles used were 19.9 degrees for the circumferential flaw test and 16 degrees for the axial flaw test. The tubing had been ultrasonically tested previously and all indications greater than 4 mils in depth and 1/2 inch in length were rejected. Many defects of greater than 2 mils were detected by the tester and verified by visual inspection.

Checkout of the cooperative program sheath tubing test station was completed and it was crated for shipping to the Geneva Conference. Prior to shipping, final prints of both the mechanical and electrical systems were completed and recordings of normal voltage wave shape patterns were obtained. This information, along with equipment photographs, is being incorporated into the production test equipment portion of the final report. Two reports, HW-81955, The Measurement of Ultrasonic Transducer Characteristics, and HW-81956, Thin Wall Tubing Tests Using Ultrasonic Shear Waves - Part I, were completed. Part II of this report (HW-81957) which describes the production test equipment, is approximately one-half completed.

Fabrication, checkout and evaluation of the tubing notch standard punch was completed. The punch tool which was machined from tool steel was attached to a milling table crossfeed. With the tubing held firmly in position, notches are punched into both the O.D. and I.D. surfaces of the tube. A differential indicator measures the depth to which the tool has penetrated. This technique allows the notches to be punched to an accuracy of 0.05 mils. Ten notches punched to a 1 mil depth showed actual variations in depth of less than 5 percent when measured optically using a 500x magnification. The amplitude at which these ten notches were detected ultrasonically also varied less than 5 percent. This notch fabrication assembly was used to punch approximately 100 notches with no apparent punch wear.

BIOLOGY AND MEDICINE - 06 PROGRAM

Atmospheric Physics

Four field experiments designed to measure the dispersion of materials released from an elevated source into stable atmospheric density stratifications were successfully completed during the month. In these tests, zinc sulfide tracer material was released for a period of one-half hour from the 185-foot level of the Meteorology Tower with air samples obtained

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to a distance of 25 miles.

The recently rebuilt Portable Mast-Micrometeorological Measurements System was moved from its testing position adjacent to the meteorology building to the field location near the ground source release point. The system is considered field operational and will improve the measurements of micrometeorological parameters associated with the atmospheric dispersion experiments. Special and routine maintenance problems peculiar to field operations were being worked out at month end in conjunction with training of operating personnel.

In studies pertaining to the area enclosed within various dosage isopleths for the "Green Glow" test series, wind variability over the downwind trajectory of the released material was further investigated. A good correlation was found in the time variation of the wind history on the three towers; one at the source point and two at downwind distances of 1.5 and 14 miles. In most cases, the wind speed was found to decrease with time at all locations during experiments conducted during slightly stable conditions. Factoring in the change of wind speed along the trajectory, a new regression equation for the area within an isopleth was obtained, which gave areas approximately 50 percent greater than was indicated in earlier analyses using source point winds only.

A surface energy model in the raindrop wetting of scavenged particles was prepared for publication. Some of the difficulties in evaluating the effect of wettability of a particle on the scavenging process were investigated. It was shown that the use of free surface energy, instead of surface tension, improves understanding of the scavenging process and points up the need for photomicrographs of the contact event.

Radiological Physics

Measurements of radioactivity in urine samples continue to give interesting results: 1) The relative amount of Cs^{134} in the Eskimos continues to decrease. In the summer of 1962 it was 1.2% of the Cs^{137}; in the summer of 1963 it was 0.67%; this January it was 0.28%. This decrease is more than that due to radioactive decay and indicates dilution with fallout containing no Cs^{134}. 2) The estimates by urinalysis of Cs^{137} body burdens of Anaktuvuk Pass Eskimos have been larger than the burdens measured by whole body counting for several months. We do not know why. It may result from the rapid changes in body burden they have been undergoing. 3) Pooled urine samples obtained monthly from Kadlec Methodist Hospital have been indicating average Cs^{137} body burdens in close agreement with those obtained at the Hanford Whole Body Counter. The rapid rise in Cs^{137} burdens that began in 1962 appears to have leveled off at

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about 20 nCi, or about twice the maximum reached in 1959. 4) The Na^{22} in urine of Anaktuvuk Pass Eskimos has been in the range 50 to 100 pCi/liter. A resident of Fairbanks, Alaska (a Summer Professor at Hanford Labs) gave 1.9 pCi/liter. Recent measurements on caribou, moose, and beef indicate (in contrast to earlier, less extensive results) that there is enough Na^{22} in these meats to account for the amounts in the people who eat them.

A forty-fold increase in sensitivity for Na^{22} resulted from using a gamma-ray coincidence system of counting. The urine of one Anaktuvuk Pass Eskimo contains 0.4 nCi/liter of Na^{22}; if his physiology is "standard" he may contain about 7 nCi; this should be detectable by whole body counting and we will look for it this summer. The presence of Na^{22} has begun to interfere with the K^{40} determinations needed for the Cs^{137} correlation in urine. Flame photometry analysis for the potassium was substituted for gamma-ray counting.

Preparations for the summer's work in Alaska were completed. The equipment has been shipped and personnel will leave early in July.

The plutonium X-ray counter was used to measure Pu^{238} in rat feces and urine from Biology experiments. The method is a quick one; little sample preparation is required.

The positive ion Van de Graaff developed a voltage instability. About half the month was lost trying to fix it. Many things were done to the machine and the instability finally disappeared.

Use of xenon proved impossible in our proportional counter neutron spectrometer at the pressure we had planned to use it. At the high pressures the resolution of the counter was very poor. We plan to try krypton next.

Instrumentation and System Studies

Experiments continued on development of miniaturized circuits for the animal physiological function and dose telemetry system. A bias-controlled tunnel diode oscillator circuit was designed and tested for operation at 100 Mc/sec; however, the available audio frequency change was inadequate. Several new commercial miniaturized blood pressure and respiration rate transducers are being obtained for application to this project.

Experiments were conducted at the Biology Inhalation Laboratory with the completed automatic smoke inhalation control system using three dogs. General operation was satisfactory following minor circuit adjustments. Automatic control of the air to smoke ratio from 1:1 to 11:1 was achieved. The nose masks are being modified to better fit the muzzles of the dogs.

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The Biology dog counting system was improved with design of the mechanical portions of the scanning drive and fabrication of both the track bed and cart. Assembly of the modified system is being accelerated as the new phantom was received. This will facilitate the testing of the new scintillation detector assemblies.

The completed alpha energy analysis air monitor was delivered to the intended Biology Laboratory location and only attachment to the appropriate air system is needed before general operation commences. A complete instruction and maintenance manual is being written.

Experimental work was continued on a solid state detection and circuitry combination neutron-gamma monitoring system for use in the measurement of neutron and gamma dose rates under mixed field conditions. A low noise preamplifier, using two field effect transistors in a cascode connection, was developed and is being tested. One surface barrier diode detector was installed in a 25 cm diameter polyethylene moderator and tested with a PuBe neutron source. Satisfactory results were achieved and arrangements were made to utilize the positive ion Van de Graaff for further tests.

A developed tunnel diode discriminator circuit was used successfully with an EMI-9530 QA 5-inch phototube to monitor an Fe-55 radionuclide source. The 5 keV spectrum was 2.5 keV in width at the half-maximum points. Background noise interference was minimized using the developed pulse shape sensitive coincidence circuits. Design was initiated on an improved circuit technique. The circuits are being developed for use in dosimetry studies.

The necessary logic circuitry was designed for use in the peak pulse reader instrument, which will be employed to provide readout from pulse ion chamber reading instruments. Four decades of coverage are required to insure adequate readout characteristics. Amplifiers followed by integrators connected to a commercial digital voltmeter are being employed. Reed relays are employed to connect the appropriate integrator to the DVM and 0.8 msec reed relay operation is being achieved.

Work was accelerated on the improvements being incorporated in the remote data stations for the Atmospheric Physics radiotelemetering system. Two modified data stations were completed in prototype form and five more stations are being similarly modified in the 328 Building electronics shop. As a final change, reed relays were incorporated to eliminate the chronic problems caused by the original stepping switches.

The logic and delay circuits were developed and fabricated for use in a pulse rise time discriminator instrument to be used in dosimetry studies. Circuit revisions were incorporated to insure operation over a 34 dB dynamic range. The process will take the logarithm of the input signal

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using fast diodes; the resultant will be sliced to determine the 10% and 90% points of the pulse.

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis Program

Isotopic analyses were provided on program samples as received this month.

Installation of the new magnet-sweep coil of the program mass spectrometer was completed and the necessary focusing adjustments were made. Modifications to the gate timer of the ion-counting system were made to provide more convenient counting intervals of 1, 2, 4, and 10 seconds.

The alumina parts for a vacuum-lock sample changer for the mass spectrometer have not been received.

After 21 months of service the electron multiplier ion-detector of one of the heavy-element mass spectrometer ("A") became intolerably noisy and had to be replaced. A series of analyses of NBS uranium isotopic standards has been started to determine the linearity of response and degree of mass discrimination of the new electron multiplier.

EXPERIMENTAL REACTOR PHYSICS FACILITIES

PCTR Operation

The PCTR operated routinely during the month. There were no unscheduled shutdowns. It was operated twice for the University of Washington Graduate Center. Measurements were completed to determine the epithermal cross section of zirconium. Neutron absorption measurements were made on styrafoam, "Lucite," "Lexan," scotch tape, scotch pressure sensitive tape, and "Marks-A-Lot" ink. The graphite R&D neutron spectrometer equipment for making in-pile measurements was checked out in the PCTR. Two sets of foils were irradiated for normalization purposes.

TTR Operation

The TTR was not operated during the month. A proposed improvement to the TTR interlock circuit was investigated and revisions will be made when authorized. A pre-startup test switch is planned which will allow observing the action of the safety circuit channels with neutron source in and out of the reactor before pulling the safety sheets. In the test position, the switch also drops safety rods and sheets.

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Critical Approach Facility

The critical approach experiments, with light water-moderated EBWR fuel rods in 0.60, 0.90, and 0.93 inch lattices were completed during the month. These rods are Zircaloy clad with 3/8" fuel core diameter and are 1.50% PuO_2 in UO_2 containing 0.22% U-235. Exponential data were obtained at 45%, 50%, and 60% of the critical loading for the 0.90 inch lattice.

PCTR and TTR Operating Safety Limits

Operating Safety Limits for the PCTR and TTR have been prepared jointly with personnel of the AEC Production Division and Health and Safety Division, and with Nuclear Health and Safety personnel in Programming. As a basis for Operating Safety Limits to be issued by the Commission, HW-82761, Physical Constants Testing Reactor and Thermal Test Reactor, Operating Safety Limits, was forwarded to the AEC Production Division by Nuclear Health and Safety.

COMPUTER FACILITIES

A work order was issued to J. A. Jones for the procurement and installation of air conditioner equipment needs for installation of the G.E. 412 computer. The second round of proposals for a van to house the computer were reviewed. The purchase order has been placed; the van will be assembled in Seattle.

The analog computer utilization was as follows:

EASE 1132	EASE 2133	
124	117	Hours Up Time
29	39	Hours Scheduled Down Time
7	4	Hours Unscheduled Down Time
160	160	Hours Total

In addition, the 2133 computer was used on swing shift for 87 hours. Problems considered during the month were:

1. N Reactor.
2. PCTR Hazards Analysis.
3. ANN Recovery (CPD).
4. Reactor Model Gas Loop.
5. Radioactive Decay Problem.
6. N Reactor Cold Water Injection.

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CUSTOMER WORK

Weather Forecasting and Meteorological Services

Meteorological and Climatological Services included 1) determination of periods of precipitation on Rattlesnake Mountain for use in dating rain samples for HL, 2) determination of periods of highest temperature at which 90% or greate relative humidity could be expected for NRD, 3) meteorological aspects of release of land to the State of Washington for HL, and 4) prepared special river forecast for peak stage expected at N-Reactor for NRD.

Meteorological factors relating to retention of land on the Wahluke Slope were summarized for presentation to the Advisory Committee on Reactor Safeguards at the request of the AEC. Presentation was made on June 19 at AEC Headquarters.

The final river flood stage forecast was made during the month. During the balance of the water year, which ends September 30, flow rates are expected to average much above those of last year while temperatures are expected to average much lower. The following are predicted monthly average figures at Priest Rapids with flow rates given in thousands of cubic feet per second and temperatures in degrees Centigrade:

	Flow Rate	Temperature
July	300	16.2
August	150	17.5
September	85	17.2

Weather Summary

Type of Forecast	Number Made	% Reliability
8-Hour Production	90	85.4
24-Hour General	60	85.4
Special	179	89.4

June was a little cooler than normal and precipitation totalling 0.90 inch made this the first abnormally wet month since December. In fact, there was more precipitation during the first eight days of June than in the previous five months combined.

Mass Spectrometry

Isotopic analyses were provided on one plutonium sample in support of the Plutonium Regenerating Detector Experiment of Nucleonics Instrumentation

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and one uranium sample in support of HAPO U^{233}-production studies.

Analyses were completed on pre-irradiation uranium samples in support of U^{236} buildup study of IPD Research and Engineering and a summary report (HW-82766) was issued. Isotopic analyses were also performed on samples of one plutonium and three uranium flux detector pins used in experimental studies by Reactor Lattice Physics.

Instrumentation and Systems Studies

At the request of the Chicago Operations Office, AEC, a Hanford Model 1004 eddy current testing system was shipped to Elk River, Minnesota, and used to assess the condition of stainless steel tube installed in the No. 1 primary evaporator. The I.D. of the tubing was found to be less than the nominal 0.620 inches, and only a limited number of tubes could be examined. Of the twenty-six tubes which were examined, two were found to contain indications of gross defects originating on the outer surface. In addition, many of the tubes were extremely noisy, and this reduced the over-all effectiveness of the test. It is anticipated that further testing at the site will be requested.

The possibility of ultrasonically inspecting the homogeneity of solidified wastes appear more promising as a result of tests which showed that solid-to-container bonds on experimental samples transmitted usable amounts of ultrasonic energy. Work is in progress on the fabrication of a turntable system to run tests at temperatures to 400°F.

The Eddy Current Motion Analyzer (ECMA-I), which was developed for use in studying the fuel assembly vibrations that have been encountered in the PRTR, has been tested in the EDEL-I loop. During this test period some operational problems were encountered, and an extensive series of tests were initiated to determine the thermal characteristics of the coils and lead wires. The component testing series is about 75% completed, and present indications are that the swaged lead wires will require replacement due to their unpredictable high temperature characteristics. Testing of the coils has only been partially completed.

Design progress was achieved on the solid state circuitry for use in the aerial monitor for Environmental Monitoring, HL. A five-inch diameter NaI(Tl) crystal was returned to the manufacturer for re-canning. A new count rate meter circuit is being incorporated to drive the 1 mA chart recorder with adequate response time. The design eliminates the need for an operational amplifier required by the original monitor.

Engineering assistance was provided to Advanced Fuels Development, HL,

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regarding measurement of current, voltage, and weld energy for the AFD resistance welder. Weld current and voltage waveforms are being plotted and attempts are being made to devise an analog-type weld energy computer. Additional work is being done to improve the methods of measuring welding electrode pressure; however, the inherent high magnetic fields are impeding progress toward a solution.

Satisfactory test results were obtained with inner detection head assembly for the face mask monitor being developed for use at the HAPO Laundry Facility; however, extreme difficulties were encountered in fabrication of the rather complex outer Lucite light pipe. A special assembly is being fabricated to hold the Lucite pieces during the gluing process.

A high temperature gas loop being constructed by Reactor Fuels Research and Development for evaluation of materials under high temperature environments is being simulated on the analog computer. The gas loop has been split into the following segments for study:

1. Flow Equations.
2. Gas Feed Injection.
3. Water Cooled Heat Exchanger.
4. Regenerative Heat Exchanger.
5. Heater, Pipe Loss, and Test Section.

The basic equations for each section of the process have been defined. The flow equations and regenerative heater equations have been patched for analog computer simulation. Initial study of the flow equations indicates that one of the major control valves may be improperly sized for best operation of the valve because the valve will be required to be practically closed most of the time to control the process.

An analysis of the PCTR hazards was undertaken during the report period. Reactivity excursions of ramps or step inputs were used. Termination of the excursion was by a rod drop or by fuel element melting. All equations and values for constants were received and the program was set up for the EASE 1132 analog computer. All results have been discussed with the customer.

A rough draft report has been written for the 6144 channel time-of-flight analyzer. Logic and circuit diagrams for the report are being prepared.

A rough draft report has been written for the transport lag simulator. Issue will follow clarification of patent consideration.

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Design work was completed on a digital temperature programmer to be used by Physical Metallurgy for temperature cycling a stored energy calorimeter. The calorimeter is almost completely reassembled, and it is expected that the controller tests will start within a few days.

A data acquisition system was designed for experiments planned under the containment program and an estimate of equipment cost submitted. The system proposes the use of a small digital computer to control the acquisition and storage of data. The computer will also produce partially reduced information for quick work requirements.

Work has been initiated on developing foolproof instrumentation capable of revealing operation of supposedly shut-down reactors. Planned for installation in decommissioned U.S. and foreign reactors by international agencies, this equipment would insure that reactors were left idle in accordance with international agreement. Technical methods of meeting the required objectives are being investigated.

Optics

The use of a silicon photovoltaic cell to study the temperature variations in a graphite welding operation as a function of time was demonstrated. A silicon cell was installed on the welder and its output monitored with a memoscope. The cell was calibrated by use of a carbon arc and slit so that its output could be correlated to temperature. Comparison of calibration curves to the memoscope trace allowed an estimate of the weld sample temperature during each portion of the weld cycle. Specifications were written for parts and equipment necessary for a permanent installation which will include area and temperature resolution at both the high and low ends of the temperature range.

The two-foot electrical readout traverse mechanism was used for horizontal bowing measurements of C Reactor. A test stand is being fabricated to calibrate the N Reactor traverse mechanism. A formal report is being written to describe the construction, principles of operation, and use of this device.

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

1. One thousand stainless steel rods were coated with aluminum for Advanced Fuels Development.
2. Pulleys and support blocks were fabricated for the Geneva eddy current display.
3. Assistance was rendered in fabricating parts for a notch punch instrument.

4. Fifty brazing bell jar windows were tested for flatness for use at N Reactor.
5. An underwater viewer at KE Reactor was serviced.
6. Two laser crystals were coated with silver.
7. Two crane periscope heads were repaired for each Purex and Redox.
8. Ultrasonic test samples were coated and machined to specifications.

Physical Testing

Radiographic inspection service was provided N Department over a holiday weekend to detect internal flaws in castings on high pressure valves. One flaw had resulted in a crack on the surface. Several flaws were located and the larger ones were repaired by welding and then re-inspected before being certified by the technicians.

Meticulous examination of ten complete lengths of tubing removed from the Steam Generator 4-A at N Reactor is completing the program of locating the position and orientation of intergranular defects in the tubes. The results of the year-long program of laboratory studies on the steam generator problem are being compiled in final reports for the final settlement in July of this year.

Leak testing with the new techniques of sound detection are becoming an increasingly important solution to numerous plant problems. Two of the latest examples are: the detection of leaks in buried export water lines, and leaks in lead-sheathed telephone lines. The latter was directly beneath a lashing, not detectable by other means, had admitted water, caused corrosion of the wire bundle, and disrupted communications in wet weather.

Instrument engineering support to Plutonium Metallurgy Operation has resulted in the successful development of the capacitor discharge system to instantaneously heat metallic specimens. Initial discharges were made using electrically fired explosive detonators for switching. To save detonators an alternate switching method of withdrawing mylar film between two copper plates was developed. Discharge times and heating rates were the same for both switching systems.

INSTRUMENT EVALUATION

Comparison tests between RCA-6655-A phototubes and EMI-9536-B phototubes indicated that pronounced operational improvement could be obtained using the EMI tubes in the combination alpha-beta-gamma hand and shoe counters. Further tests indicated that general performance could be further enhanced

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by using transistor preamplifiers with the eight detection probes used in each counter. The EMI tubes and preamplifiers are being incorporated in three of the ten counters to permit acquisition of field test data. The use of preamplifiers, which have a voltage gain of about 25, permits operation of the phototubes at a considerably reduced high voltage.

Acceptance tests were started on 100 new CP type portable exposure rate measuring instruments. Only very minor changes appear to be necessary to insure proper field operation of the offsite fabricated instruments.

R S Paul

Manager
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RS Paul:mcs

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CHEMICAL LABORATORY

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 02 PROGRAM

SEPARATIONS PROCESSES

Sodium Sulfoxalate Formaldehyde as Plutonium Reductant in the Purex Process

Satisfactory partitioning of plutonium was obtained in a miniature mixer-settler run simulating the Purex partitioning column (1B) with sodium sulfoxalate formaldehyde (SFS)-hydrazine instead of ferrous sulfamate as the plutonium reductant. Neptunium is reduced to neptunium(III) by SFS in nitric acid solution. However, when uranium(VI) is present in excess of that required to react with SFS, neptunium is present as neptunium(IV).

Metathesis of UF_4

Potassium hydroxide proved superior to sodium hydroxide for metathesis of uranium(IV) fluoride left in a dissolver after Zirflex decladding of uranium metal. Metathesis of uranium(IV) fluoride to uranium(IV) hydroxide proceeded rapidly in 2 M potassium hydroxide solutions containing up to 4 M potassium fluoride. Metathesis in 2 M sodium hydroxide proceeded slowly if at all when the sodium fluoride concentration exceeded about 0.3 M.

Ion Exchange Safety Tests

Evaluation of anion exchange resin thermal-chemical stability continued with engineering scale tests to evaluate potential emergency venting systems for the Purex Plant contactor. Results to date with nitrated resins show that very simple pressure relief systems are adequate. Tests with thorium loaded resin are planned.

Thorium Studies

In thorium denitration studies, a batch of $Th(NO_3)_4 \cdot 4H_2O$ was pot denitrated at $\sim$ 540 C in a steam atmosphere. The oxide product formed a stable sol.

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Spray Calcination of Thorium Nitrate

A number of spray calcination runs have been made during the month to further evaluate the potential of this technique for the production of thoria suitable for the Sol Gel process. Twenty pounds of thorium nitrate were calcined (725 C) in the 8-in. calciner, producing 8-1/2 pounds of thoria. The product had a surface area of 5.2 m^2/g (by B.E.T.); a crystallite size of 169 Å (by X-ray line broadening); and the preliminary electron micrographs looked quite similar to the micrographs for the soluble Mallinckrodt denitrated oxide (14.7 m^2/g, 38 m^2/g, and 360 Å measurements). The spray calcined product did not form a stable sol. Further comparison studies are in progress.

Besides Sol Gel evaluation, some of this material was pressed (30 tsi) into 2-in. diameter, 60 percent T.D., pellets for solubility rate studies. If dissolution rate is favorable, a reactor irradiation test will be performed.

U-233 Support Studies

Hot-cell isolation and partial purification of high-purity (1 ppm U-232) and ultra-high-purity (<< 1 ppm U-232) uranium-233 was completed during the month and the material removed to the laboratory for final purification (by ion exchange). The ultra-high-purity sample (ca. 40 milligrams) will be employed for radiochemical measurements. This isotopically pure U-233 was produced by decay of Pa-233 which was isolated from fresh thorium dissolver solution by manganese dioxide scavenging.

In associated laboratory work, evaluation continued of Vycor, silica gel, and other similar adsorbents for protactinium removal. Use of Drifilmed glassware reduced sorption of Pa-233 on the experimental equipment and resulted in improved decontamination factors which compared more favorably with those reported by Oak Ridge; however, the highest was still only about 10. Increasing thorium concentration caused decreasing decontamination in all cases studied. Column experiments were initiated with the more promising adsorbents. Several, including unfired Vycor, exhibited very poor mechanical behavior in the column. These studies are continuing, but because of the above difficulties scouting work was also initiated on head-end scavenging agents. Preformed MnO_2, SnO_2 and PbO_2 gave decontamination factors as high as 250.

Technetium Processing

Analyses of the purified pertechnetate were completed during the month, 80 grams of technetium present in various waste solutions was reworked, and equipment was assembled for hydrogen reduction of ammonium pertechnetate to metal.

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Spectrographic analysis of the pertechnetate shows no metallic impurities present above 50 ppm. Radiochemical analyses show only Ru-106. The ratio of Ru-106 activity to Tc-99 activity is only 4.8×10^{-5}, corresponding to an overall decontamination factor of ca. 10^{10} (starting with Purex supernate).

Pu-238 Gamma Dosage

Calculations and measurements are under way to determine the contribution of other isotopes (e.g., Tl-208 from the Pu-236 decay chain) to the radiation dosage from Pu-238 isotopic heat sources. A gamma scan was made during the month of a sample of Pu-238 obtained from ORNL. The Pu-238 content of this material was about 80 percent. The spectrum contained the 0.76 mev gamma of Pu-238 in about the expected amount as well as the 2.61 mev gamma of Tl-208 in an abundance only slightly less than the Pu-238 gamma. Three unexpected gammas were also found: at 0.86, 1.27 and 1.78 mev. All three gammas were present in about the same amount as the 0.76 mev plutonium gamma and would thus contribute significantly to dose rate if present in a Pu-238 heat source. These peaks were absent from the scan of a second sample of Pu-238 (containing about 90 percent Pu-238 and in the form of an aqueous solution), strongly suggesting that they were due to the N-14 (α,n)O-17 and F-19 (α,n)Na-22 reactions on air and fluoride impurity, respectively. The Tl-208 content of the second sample was about five-fold higher than in the first. Since the age and past history of the two samples is unknown, no final conclusions can be drawn except that Tl-208 does indeed contribute significantly to the gamma dose rate from Pu-238. Attempts are being made to (1) trace the history of the samples, and (2) determine Pu-236 directly. Determination of U-234 may also prove possible and helpful. Failing these approaches, repurification and determination of Tl-208 growth as a function of time should prove conclusive; however, it is estimated that a minimum of six months would be required before meaningful counting levels would be achieved.

Destructive Irradiation of n-dodecane

A sample of n-dodecane given an irradiation dose of 6×10^8 r has been examined in regard to decomposition products. About six new low molecular weight compounds were formed but no high boiling material was indicated by the vapor phase chromatograms. Separate portions of the irradiated sample were washed with water, 6 M HNO_3, 1 M Na_2CO_3 and 0.1 M $KMnO_4$. Little reaction was indicated during the washes and the gas chromatograms indicated no appreciable change in the samples.

Although about 40 percent of the original molecules were altered by the radiation, the major products were apparently stable saturated hydrocarbons.

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Disposal to Ground

At the request of Radiation Protection and Purex Operations, assistance is being provided to determine the contamination status and possible remedial action to be taken as a result of the discharge of greater than normal amounts of mixed fission products to the Gable Mountain Swamp due to a recent cooling coil failure. Scintillation probe traverses of the swamp showed highest radiation readings at the east (inlet) end and at the west (recently inundated) end. Quite evident from the survey is the concentration of radionuclides by algae growing on near-surface and shoreline vegetation. Although a reduction in water activity will occur due to radioactive decay and soil infiltration, it appears desirable to hasten the natural cleanup processes by destruction of the algae. Also, control of shoreline contamination, possibly by raising the level of the swamp, appears desirable.

WASTE MANAGEMENT AND FISSION PRODUCT EXTRACTION

Kinetics of Ion Exchange on Zeolites

The self-diffusion coefficients of strontium, cesium and sodium with erionite, phillipsite, clinoptilolite, Type X and Type A zeolites, and of cerium with Type X zeolite, were determined on two grain sizes at 50 C. Total solution normality was 0.2. Self-diffusion coefficients ranged from 2.40×10^{-9} cm^2/sec for cerium isotopic diffusion in Type X to 1.43×10^{-6} cm^2/sec for cesium isotopic diffusion in erionite. The self-diffusion coefficients will be used to compute an exchange diffusion coefficient, based on a kinetic model proposed by Helfferich(1).

The calculated exchange diffusion coefficients will be compared with experimentally determined exchange diffusion coefficients.

Strontium Semiworks Solvent Wash Studies

Although less effective than fresh or laboratory-grade solvent, the current inventory of washed (sodium hydroxide-tartrate and nitric acid-oxalate) solvent appears satisfactory for separating cerium from other rare earth elements. Precontact of the SSW solvent with $K_2S_2O_8$-$AgNO_3$-HNO_3 solutions did not improve cerium distribution. However, cerium distribution was increased by using higher than normal concentrations of potassium persulfate and silver nitrate during the extraction step. Current studies are aimed at determining the effect of degraded diluent on cerium extraction by SSW solvent.

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(1) F. Helfferich and M.S. Plesset, "Ion Exchange Kinetics. A non-linear diffusion problem." Jour. Chem. Physics, 28, 418-424. (1958)

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Strontium Purification by Solvent Extraction

The presence of solvent degradation products in the CSREX solvent used appears responsible for the low calcium decontamination factors and high strontium loss experienced in pilot scale studies on strontium purification reported last month. Both strontium and calcium strip more slowly from solvent containing degradation products than from freshly prepared solvent.

Cesium Recovery from Alkaline Wastes

Engineering scale studies continued on the use of inorganic zeolites for recovery of cesium from alkaline wastes. Based on the study of the operating parameters and scale-up factors, it is concluded that the present plant design parameters of two column volumes per hour, 2 gal/min/ft^2, and 40 column volumes loading are conservative. It may be feasible to process 60 column volumes before elution, thereby reducing the volume of the column by one third.

In-Tank Solidification

A decision was reached in conjunction with CPD personnel to proceed with a plant test of the immersion heater concept as a second generation in-tank solidification unit. The plant test will be conducted in the same waste storage tank (101-BY) in which the prototype hot air evaporator is located, and will utilize available spare equipment and services from the prototype. Overall geometry and power rating of the individual heater elements have been defined, factoring in the power requirements of the second generation unit and the surplus power available from the prototype system now being installed. Three immersion heater units of 120 kw each are planned.

Irradiation of H_2-O_2-H_2O-Zeolite System

It was previously shown that the irradiation of a mixture of hydrogen and oxygen over dried zeolite resulted in the steady decrease of the hydrogen and oxygen concentrations. The experiment has now been repeated using "wet" zeolite (total $H_2O \sim 25$ w/o). The hydrogen and oxygen content steadily decreased on irradiation. After a dose of 1.6 x 10^7 r the hydrogen had decreased from 48 percent to < 1 percent.

Experiments have begun on the reverse reaction, the irradiation of water on zeolite. No significant pressure change has been detected up to a total dose of 2 x 10^7 r. No analyses have yet been obtained on the gas above the zeolite.

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Further experiments will involve different initial compositions, the effect of impurities and longer irradiation times. These preliminary experiments suggest that a relatively low equilibrium pressure may indeed exist over zeolite beds.

Waste Packaging Studies

Various methods of measuring the pressure from gas radiolysis in packaged wastes have been considered, recognizing the need for container integrity and the fact that measurement will be required over long periods of time in high radiation fields. In the present study, the primary sensor is a Bourdon tube attached to the container via a welded capillary tube; readout is accomplished by a linear variable differential transformer. Measurements with this system indicated linearity and hysteresis are within 1 percent over the 200 psi span. Further studies showed the basic hysteresis of the Bourdon tube is less than 0.1 percent.

Alkali Metal Extraction by CSREX Solvent System

Recent studies of the extraction of alkali metals by the CSREX solvent system (BAMBP-D2EHPA) have yielded results consistent with the following hypothesis:

1. In the absence of a phenol, alkali metal-alkylphosphate salts are formed which are insoluble in either organic or aqueous phase, and which contain water solvated cations. When concentrated alkali nitrate is present in the aqueous phase, alkali nitrates extract as the organic acid is neutralized and the resulting organic salt is soluble when this "extra" alkali nitrate is present. The reason for this solubilization by the presence of the alkali nitrate is unknown. It is significant that the order of extractability is the same as of the order of stability of the hydrates, i.e., $Na^+ > K^+ > Rb^+ > Cs^+$.

2. When an organic soluble, substituted phenol is present in the organic phase along with the alkylphosphoric acid the salt formed upon neutralization of the acid with CsOH contains a phenol solvated cation. The order of extractability is reversed by the presence of the phenol because this solvating agent is organic soluble and is in direct competition with the solvating effect of water which tends to hold the ions in the aqueous phase. Thus, the ion which is least solvated in the aqueous phase (Cs^+) is most efficiently extracted into the organic phase where it is simply solvated by the phenol which apparently can cause any of the salts to be organic soluble.

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Results of both infra-red measurements and nuclear magnetic resonance measurements of the extracted organic species are consistent with a mechanism in which the phenol-solvated molecule $M^+D2EHP^- \cdot 4$ phenol is the organic-soluble species, the phenols are hydrogen bonded to each other, and the strength of the bond between phenols increases as the size of the cation M^+ increases.

EQUIPMENT AND MATERIALS

Corrosion of Boron-Containing 304-L Stainless Steel

Corrosion for as-rolled 304-L stainless steel containing one weight percent boron in boiling nitric acid increased from 0.14 to 3.2 mils/mo as nitric acid concentration increased from 20 to 65 weight percent. These rates are about double those expected for 304-L without boron. The 304-L-B alloy, when sensitized, corroded more than 25 times as fast as 304-L in boiling 65 w/o HNO_3. In boiling Zirflex decladding solution the 304-L-B alloy corroded at 45 mils/mo or about three times as fast as 304-L.

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REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Dissolution of PRTR UO_2-PuO_2 Fuels

The "most promising" procedure devised to date for dissolving PRTR UO_2-PuO_2 fuels in the Redox annular dissolver may not be usable because of potentially severe corrosion of heat exchanger tubes. Laboratory studies this month disclosed no satisfactory alternative procedures. Little, if any, dissolution of plutonium dioxide occurred in boiling nitric acid-ammonium fluoride solutions containing adequate aluminum nitrate to adequately protect stainless steel from corrosion. Prolonged exposure of non-irradiated plutonium dioxide to Zirflex decladding solution will convert it to a form subsequently soluble in nitric acid-aluminum nitrate solutions. This approach was not effective for dissolution of irradiated fuels, presumably because of sintering and agglomeration of the oxides during irradiation.

Process Engineering Development

In exploratory hot cell studies of Salt Cycle processing of 30-pound lots of irradiated UO_2 fuel, a highly successful by-product electrodeposition was accomplished in which UO_2 was separated from plutonium by a factor of 1000. The high oxygen content (O/U ratio of 2.10) of a mixed UO_2-PuO_2 product recovered in the co-deposition step in an earlier run was successfully reduced to an acceptable level (O/U ratio of 2.005) by hydrogen reduction.

Radiochemical analysis of product produced in February under codeposition conditions showed decontamination factors on plutonium basis for Y-91, Ce-144, Pm-147 and Eu-154 of 2.3, 7.3, 2.8 and 2.5, respectively. Decontamination factors on a uranium basis for Am-241 and Cm-242 were 6.6 and 12.0, respectively.

Fuel Burn-Up Measurements

Work continued on the direct method for determining Cs-137 in mixed fission products. The method, which is based on β-γ anticoincidence counting, depends on its discrimination efficiency on very efficient beta counting. Several beta scintillation methods have been tested, including the use of liquid, solid and gel phosphors. The gel scintillator, NE 211 (Nuclear Enterprises), is very promising. At ratios of gel to liquid sample of 100, 500 and 1000 to 1, beta counting efficiencies for Zr-Nb-95 were 94.1 percent, 95.1 percent and 95.8 percent, respectively. The beta efficiency for Ru-Rh-106 was 99.9

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percent. With this technique, using gamma spectrometry but rejecting all gammas coincident with a beta, Cs-137 can be determined to better than ± 1 percent in a 1.5 year old fission product mixture.

RADIOACTIVE RESIDUE PROCESSING DEVELOPMENT

Cold Semiworks Spray Calciner

Previous studies using feeds compatible with stainless steel melters have exhibited some wall caking problems. Use of insoluble calcium borate (colemanite) rather than sodium tetraborate in the feed to make glass apparently alleviates this problem. A dense, yellow powder was obtained with no operational troubles, i.e., no wall deposits, no filter plugging, no nozzle plugging, etc. The powder melts to a glass at ca. 1000 C.

Spray Calciner-Melter

The coupled spray calciner melter was operated with Purex waste containing cold fission products and phosphoric acid for glass formation. Filter blinding was encountered. Equivalent ratio of phosphate to metal ions was approximately two in the Purex feed compared to other runs in which the ratio was one or less. Removal of phosphate from the cold fission product bearing feed gave satisfactory operation.

Melter Corrosion

The upper temperature limit for 310 stainless steel in waste melter environments appears to be about 1000 C. Catastrophic corrosion generally occurs at temperatures of 1100 C or greater. For this reason, 310 is not a promising material of construction for a general purpose waste melter. In initial tests a new chromium-nickel alloy obtained from the Paper and Pulp Research Institute of Canada shows promise as a material for waste melters. When exposed in a Redox waste [with added colemanite ($Ca_2B_6O_{11} \cdot 5H_2O$)] melt at 1100 C, it corroded at about 10 mils/mo based on weight loss.

Hot Cell Operations

A pot containing spray-calcined Purex waste (with phosphate additive) was transferred to Radiometallurgy for sectioning, three other pots were set aside for long-term surveillance, and steps were taken to dispose of all others. In the meantime, clean-up work has begun on the A-Cell spray calciner and associated equipment - to simplify the eventual cell decontamination and to make room for the hot cell glass experiment. The spray column is being flushed down and the electric leads have been

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disconnected and removed. The filters and top cover are to be removed for better flushing and for mechanical scrubbing of the column interior. Other equipment not needed for the glass experiment is being removed, and the off-gas system is being refurbished.

Equipment for glass making is being received from the shop, and assembly in the mock-up area should soon begin.

Glass Composition Studies

Investigation continued on the effects of composition on the properties of phosphate glasses. Included in the month's activities were further study of phosphate loss, measurement of solubility of glasses proposed for the Hot Cell Glass Experiment, effect of rare metals (Ru, Rh, Pd) on drip temperature, and reproducibility of measurement. Details are given in the April-June Waste Fixation Quarterly Report.

Intermediate-Level Waste Treatment

A 50 ml/min, three-cell electrodeionization unit was tested on acidic and alkaline Purex process condensate. Ruthenium decontamination factors in excess of 100 were obtained for the acid condensate and ranged from 50 for Dicalite-filtered alkaline condensate to > 100 with filtered and steam stripped alkaline condensate. The resin used in the deionizing chamber was a 1:2 volume mixture of Dowex 50W - Dowex 1, 20 x 50 mesh. The available membrane transport area was 247 cm^2 operated at a current density 0.0033 amp/cm^2 (3 amp/ft^2) and a linear velocity through the resin channel of 2.5 cm/sec (0.08 ft/sec). A total of 2600 bed volumes of feed was treated prior to dismantling the unit for inspection. Greater than 90 percent of the ruthenium on the resin was eluted with 6 N HNO_3 prior to inspection. The resin was discolored about 40 percent of the way through the resin channel. It is not yet known whether this corresponds to the degree of loading or whether all transport and deposition of ruthenium was occurring in this volume.

Columbia River Studies

One of the objectives of the Columbia River radionuclide transport studies is the measurement of the travel time of radionuclides in the Columbia River between the reactors and the mouth of the river for various river flow volumes. The travel times between the reactors and Pasco have been measured previously by several methods; however, the travel time between Pasco, Washington, and points down stream to Portland, Oregon, has only been determined for one river flow volume. During the period of peak flow of the Snake River in the first week of June, travel times between Pasco and Umatilla, the Dalles and Vancouver were determined

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by measuring the Na-24 concentrations at these locations and correcting for dilution by the tributaries. These measurements showed the travel time between Pasco and Vancouver to be about three days. The concentrations of several other radionuclides in these samples are also being determined to permit a calculation of their depletion, if any, during this high flow period. Na-24 appears to be an excellent tracer for the measurement of travel time. By using the multidimensional analyzer method, Na-24 can be precisely measured at a concentration 100 times less than that observed this month at Vancouver.

CONTAINMENT SYSTEMS EXPERIMENT

Major Facilities and Equipment

Modifications to T-Plant progressed on schedule. By the end of June, the canyon will be ready for containment vessel erection except for a minor amount of concrete demolition, decontamination and finish work.

The scope drawing for the air sampling and vacuum system was approved. Instrumentation scope was partially completed with the assistance of Instrument Research and Development personnel. Two alternate systems are being considered for acquisition and recording of the large amounts of data including transient pressures, strains and temperatures, as well as sample counting. One system uses conventional high-speed recorders for the transient data and a conventional 400 channel analyzer for sample counting. The alternate system converts the transducer outputs to digital form for accumulation and recording. This system, although more expensive by about $20,000, has the advantages of speed, flexibility and data output without the laborious manual reduction of recorder traces to tabulated or graphical form.

Fission Product Simulation and Aerosol Generation and Sampling

Preparations continued for tests to compare and select simulants for fission product aerosols for use in the Containment Systems Experiment. Twelve small UO_2 fuel rod specimens were fabricated by Ceramics Research and Development and irradiation procedures were initiated. Equipment for heating UO_2 in air and steam at temperatures up to 2000 C is being fabricated and assembled in the 271-CR building. Modification of a 400-gallon carbon steel tank for use as an aerosol receiver at operating conditions of 50 psig and 300 F has met some delays. However, testing should begin about the first of August.

Silver plated copper mesh and copper ribbon beds were tested at room temperature for iodine removal from air. Shown below are the iodine removal efficiencies at two air velocities:

Material	Size	% I-131 Removed 25 fpm	80 fpm
Screen, 4 layers	14 mesh	80	64
Screen, 4 layers	50 mesh	99.5	90
Ribbon, 1-1/2" deep	0.2 g/cc	99.2	97

The velocities approximate those expected in the samplers under the conditions of air only and air plus steam in the containment shell. These tests were made using laboratory generated iodine. The performance of the beds tested is marginal at the higher velocities and additional layers of screen or more dense beds will be needed in the samplers. The shelf life and high temperature behavior are under study.

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BIOLOGY AND MEDICINE - 06 PROGRAM

TERRESTRIAL ECOLOGY - EARTH SCIENCES

Hydrology and Geology

Three soil parameters (saturation, capillary pressure and relative permeability) are being measured in the laboratory on the same column of soil using Am-241 as a source of gamma radiation. Except for some minor instabilities in the electronic equipment, the method is giving good results.

A Fortran program which calculates the dispersion of a contaminated water front in a flow system was revised and rewritten to include the decay calculation of a nonsorbed radioisotope in the system. This enables determination of the time-rate of entry of the radionuclide into a surface stream.

Work continues on the installation of piezometer tubes in selected ground-water monitoring wells. About 30 wells will have been so modified under the present contracts (JAJ-197-A and 197-A-Rev.) when the work is completed at the end of this month.

Interest in the reopening of the Standard Oil Company of California Rattlesnake No. 1 test well exists in several organizations. The U.S. Geological Survey desires to reopen the well for heat flow and geothermal gradient studies. The AMSOC Committee for the Mohole and the National Science Foundation desire to reopen it for Mohole techniques and tests of Mohole instruments. The Brown and Root Construction Co., prime contractor for the Mohole, has indicated interest in the well for test purposes. Reports indicate that a decision may be reached in the next few months on the extent to which the well may be used. Efforts are now underway in the event the well is reopened to assure our procurement of all possible information on the basalt series applicable to present and future Hanford operations.

RADIOLOGICAL AND HEALTH CHEMISTRY

Analytical Procedures

Development continued on a procedure for plutonium in soil samples including an electrodeposition of the separated Pu for alpha energy analysis. Work also continued on evaluation of procedures for cerium and Po-210 in soil, urine and water. Four procedures for cerium under study are: (1) a ceric iodate precipitation method for soil samples, (2) a hexone extraction method for liquid samples, (3) a bis-2-ethylhexylorthophosphoric acid (HDEHP) extraction method, and (4) a

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tetra-n-propylammonium nitrate (TPAN) extraction method. The ceric iodate method is satisfactory although quite time-consuming. The hexone extraction method gave low and erratic yields from large water and bioassay samples. The HDEHP extraction method gave very promising results with soil, urine and water samples. The TPAN extraction method, although conveniently simple and rapid, give poor yields. All four methods gave excellent decontamination from Ru-106, Zr-Nb-95, Sc-46 and Th-234. The results of the tests made to date are summarized in the following table:

Per Cent Recovery of Selected Cerium Procedures

	Matrix			
Procedure	Spike	Tap Water (1000 ml)	Soil (2g)	Urine (200 ml)
1. Iodate	-	-	77	-
2. Hexone	77	30-70	-	-
3. TPAN	91	68	65	80
4. HDEHP	> 99	92	73	88

The two procedures for Po-210 in urine are (1) direct deposition on a nickel disc, and (2) preliminary separation of Po on nickel powder followed by redissolution and deposition on a nickel disc. The first method gave a 62 percent recovery of Po-210 from acidified urine while the second gave an 87 percent recovery. The direct deposition method is quantitative for Po-210 from 1000 ml tap water samples. The yield of direct deposition method was increased to 84 percent by preliminary treatment of the urine with HCl + H_2O_2, and was increased to 90 percent by preliminary evaporation of the urine to dryness several times with HNO_3.

Attempts to apply the direct deposition method to soils by using preliminary acid leach treatments were relatively unsatisfactory.

ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Aerosol Sampling Study

Particle deposition was observed on the brass nozzle (7.6 cm long with a 1.11 cm opening) used for isokinetic sampling at 30 mph windspeed. The fractioned deposition was found to increase rapidly with increasing particle size up to 10 μ. Losses to the sampling tube surfaces may be approximately 40 percent of the total sample.

Experimental photographs of the trajectories of particles approaching a filter were obtained using non-isokinetically introduced poly-disperse

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zinc sulfide at windspeeds of 30 mph. A radial velocity component was discernible in the region 0.4 - 0.7 filter holder diameters (0.8 - 1.5 inches) upstream of the filter. Also, particles appeared to be lost to the air stream by re-entrainment from the outer 1/8 inch of the filter where a high concentration of particles deposited. These results are indicative of a significant influence of the retaining ring on filter sampling error. Sampling errors for 30 mph velocity conform to the same qualitative surface generated from all the data at lower wind velocities.

Aerosol Generation and Characterization

Lead nitrate and iron oxide were found to produce satisfactory particles with the spinning disc generator. The lead nitrate particles formed by evaporation of a methanol solution (4.73 g/ml) with a spinning disc were nearly spherical and exhibited only a slight crystalline structure. The iron oxide particles formed from an organosol (5.17 g/ml) were spherical had had a smooth surface. The organosol was prepared by diluting the Diamond Alkali Aquasol with ethanol. Iron oxide particles as large as 20 μ were produced from a 50 percent dilution without plate-out on the spinning disc.

Fallout Radiochemical Studies

Analysis of fallout filter samples for Sb-125 by both a radiochemical and a new multidimensional gamma ray method (discussed in May report) confirmed the presence of Sb-125, as well as Sb-124, in sufficient amounts for routine determination by the gamma ray method.

Comparisons of the concentrations of Y-88 (105 d), Sb-124 (60 d) and Zr-Nb-95 (65 d) in recent air samples with those observed a year ago in similar fallout samples show significant differences. While the levels of Y-88 and Sb-124 are similar to those at the peak last Spring, the Zr-Nb-95 levels are about a factor of 20 lower (as would be expected for all three nuclides from decay). Since there were no above-ground atomic detonations in 1963 and 1964, these nuclides are coming primarily from the stratospheric reservoir of weapons debris. The fallout differences observed indicate a fractionation phenomenon or a different source (in space) of Y-88 and Sb-124 than of most of the Zr-Nb-95.

ISOTOPES DEVELOPMENT - 08 PROGRAM

Promethium Purification

Effect of acidity and monovalent ion concentration (NH_4^+ or Na^+) on the capacity of Dowex-50 resin for rare earths was measured during the month. It was concluded that the rare earth feed must be less than 0.5 M in monovalent ions or a serious decrease in capacity will result.

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Four further Sm-Nd-Pr separations runs were started, two with HEDTA and two with DTPA, each at optimum concentration and pH. Object is to determine the effect of elution distance on separation efficiency. Elution distances used were 1.8 and 1.3 band lengths, compared to 2.3 for previous runs. Unless the experiments show unexpected results, this will complete the HEDTA-DTPA study.

Pneumatic Impaction

Three one-inch diameter cans of SrS were impacted during the month. Densities were 96-100 percent of theoretical. Three compactions of SrF_2 were made using the 2-1/2 inch diameter top-loading cans. Temperatures were 850, 950 and 1050 C, respectively, and fire pressure was 350,000 psi in all cases. The low temperature can failed because the temperature was below the forging temperature. The other two yielded very good results. Density in both cases was theoretical (4.24 g/cc), and the container walls were straight and uniform (± 0.010 inch).

In supporting laboratory work, SrH_2 and Sr_2Si were prepared for pneumatic impaction. Actual impaction will be delayed until the dissociation pressure of the hydride is measured (as a function of temperature) in order to set an upper limit on heat-soak temperature.

Corrosion of 304-L Stainless Steel by Nitric Acid-Pertechnetate Solutions

Liquid phase corrosion rates for 304-L stainless steel in boiling nitric acid solutions containing pertechnetate ion in concentrations up to 0.5 M were about 0.25 mils/mo. Corrosion rates in the vapor phase increased with increasing liquid phase pertechnetate ion concentration to a maximum of 0.35 mils/mo. No preferential attack occurred.

M. T. Walling, Jr.
for Manager
Chemical Laboratory

WH Reas:cf

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1237390

BIOLOGY LABORATORY

A. ORGANIZATION AND PERSONNEL

Dr. R. T. O'Brien, Sr. Scientist in the Radioecology Operation, transferred to General Electric's Defense Electronics Division in Ithaca, New York during June.

Dr. J. J. Reardon, Eastern College of Education, La Grande, Oregon, joined the Metabolism Operation as a summer professor on June 10.

H. H. Jones joined the Radioecology Operation as a summer employee on June 15, and R. E. Kane was assigned to the Experimental Animal Farm as a summer employee on June 8.

Capt. R. O. Shannon, USAF (VC), reported for a tour of duty at the Experimental Animal Farm on June 19, 1964, replacing Capt. David H. Wood, who was transferred to College Station, Texas on May 13, 1964.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 02 PROGRAM

Reactor Effluent Monitoring

Young chinook salmon monitored in regular reactor effluent at KE, after 60 days, show a higher mortality than expected. Past experience would have predicted a 3-5% mortality for control through 4% effluent groups. Current observations are 5, 5.6, 10.2, and 16.4% mortality for 0, 2, 4, and 6% uncooled effluent groups, respectively. The higher mortality may be explained by greater sensitivity of the current test fish (Priest Rapids stock) or may possibly be associated with the new zirconium tubes at KE. All fish reared in similar effluent concentration, but cooled to river temperatures, showed mortality of 4-5%.

Columnaris

Local yearling fish were shown to contain antibody against columnaris in their blood. Salmon of this year's hatch, which have never been exposed to columnaris, exhibit no antibody, nor do 15-month-old rainbow trout taken from the Yakima State Fish Hatchery where columnaris has never been identified. These results show that presence of agglutinating titer is positive evidence of a previous exposure to columnaris, and can be used as an indication of prior exposure of fish to the disease.

Thirty-six river fish taken from above Priest Rapids Dam on May 22nd showed no columnaris infection. Water temperature was 10.5 C. Samples of fish from Horn Rapids Dam continue to be negative for columnaris, with water temperatures of 18 C. It is of special interest that no columnaris has been identified at Horn Rapids Dam since Dr. Erling Ordal reported that they obtained positive columnaris from fish taken at Prosser in April. This and last year's samplings are suggestive that the Prosser Dam represents a focal point for the origin of columnaris.

BIOLOGY AND MEDICINE - 06 PROGRAM

METABOLISM, TOXICITY AND TRANSFER OF RADIOACTIVE MATERIALS

Zinc

Yearling trout fed 0.1 μc Zn^{65}/g fish daily Monday through Friday approached equilibrium body burdens of about 270 μc in about 10 weeks.

Iodine

Peak milk I^{131} concentrations of 50-100 x plasma levels occurred in sheep about 5 hours after feeding 500 μc in a single feed pellet. Milk I^{131} concentration then fell rapidly for 48 hours, subsequently assuming a more gradual decline. Plasma I^{131} values peaked at 3-5 hours, fell rapidly to a minimum at 9-13 hours, and then began a gradual increase. This is probably a reflection of I^{131} tissue uptake and subsequent release into the circulation. These results will be compared with those from a similar study with Te^{132}-I^{132}.

Cerium

To evaluate the effects of ingestion of the potential SNAP radionuclide Ce^{144}, 200 mc of the oxide were fed to an adult male miniature pig. This dose was expected to be damaging and possibly lethal. The animal failed to eat after the first day but its condition seemed to improve after the first week. On the morning of the ninth day, the animal died, probably due at least partially to experimental stresses not associated with the radionuclide administration. Grossly, the intestines appeared only moderately inflamed. Final interpretations must await histological studies.

Neptunium

A four-hour pre-treatment of female rats with Np^{237} had a negligible effect on the oxidation of leucine or on its incorporation into liver and plasma proteins.

Inhalation Studies

Mitochondria were the most active of subcellular fractions from rabbit lung tissue in preliminary tests of fatty acid synthesis. Similar results were obtained with rat lung mitochondria.

A dog with an initial deposition of 50 μc Ru^{106}-$Pr^{106}O_2$ in the lung showed a slight increase in serum glutamic pyruvic transaminase levels five months post exposure, indicating the desirability of liver function testing in this experiment.

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A dog exposed four and one-half years ago to $Pu^{239}O_2$ shows radiographic evidence of an enlarging pulmonary tumor. This dog shows cardiac enlargement, elevated arterial blood CO_2 and decreased O_2, increased respiratory rate, and lymphopenia. There is also evidence of possible mammary tumors.

A dog phantom was received from Alderson Research Labs for use in dosimetry problems. The skeleton of one of our beagles was incorporated in the phantom, which is supplied with tissue equivalent capsules for containing radionuclides, and extra skin, muscle, and fat equivalent coats for approximating the size of mature beagles in our colony.

Twenty-seven different fights were recorded in the dog colony this month, involving 60 different animals. Fifty percent of these animals required medical attention. This result of housing more than one dog per run should be considered when planning facilities for long-term studies in which the value of an individual animal could be well over $20,000.

Gastrointestinal Radiation Injury

The protective effect of shielding short segments of the intestine during supralethal irradiation may be due, at least in part, to preservation of the mechanism for bile salt absorption. In studies with rats, this absorption was reduced to 45% of normal, three days after 1500 r. Shielding a two-inch segment of the small intestine increases the absorption to 67% of normal.

A study of bacterial populations in the irradiated rat intestine indicates migration of organisms up the intestinal tract concurrent with other pathological events.

Co-carcinogens

Rats given a single intravenous injection of Ce^{144}-Pr^{144} and fed chronically on a diet containing dimethylaminoazobenzene (DMAB) were sacrificed at various time intervals to determine retention of Ce^{144}-Pr^{144} in the liver. Animals fed DMAB showed a consistently higher retention than did control animals. Thirty days after injection the DMAB group retained 8.8% as compared with 3.6% retained in the control group.

Lactation Studies

Four ewes in the late stages of lactation were milked at 1, 3, 5, 9 and 24 hours. The average production was 970 ml (range 700-1250) for the 24-hour period with good evidence for linear production over the various time intervals employed. By injecting itocin to initiate milk "let-down", a considerable quantity of milk was shown to be present in the udder after lambs have nursed vigorously. This preliminary study will be repeated next spring using more animals and at various stages of lactation.

Effects of Temperature Acclimation on Fish Metabolism

Fish injected intraperitoneally with labeled C_1 and C_6 glucose metabolized 0.14% of the C_1 glucose dose to $C^{14}O_2$ in two hours as compared with 1.9% of the C_6 glucose. The rate curve indicates a minor participation of the pentose shunt for fish acclimated at 20 C in contrast to the previously reported highly active pentose shunt for fish acclimated at 8 C.

Terrestrial Ecology

A census of the ring-billed and California gull colonies at Coyote Rapids and Ringold by the same method employed in 1961 shows a shift from the Coyote Rapids to the Ringold area and a total potential reproduction this year better than twice that of 1961.

Banding of cliff swallows along the bluffs bordering the Columbia River was initiated, using mist nets raised some 30-40 feet above the ground to catch the birds. Bands were placed on over a thousand adult birds. It was observed that the adults, upon becoming enmeshed in the mist nets, disgorged their insects. By placing plastic sheeting under the nets, these disgorged insects could be collected for taxonomic and radionuclide analysis. This technique represents a unique method of determining food habits of the birds, radionuclide intake of young, and thus potentially a direct analysis of a food chain from river to young birds.

Plant Nutrition

An extensive series of tests on the uptake of iodide yields data which are most easily interpreted in terms of a metabolic uptake and translocation process. Iodide uptake was measured under varying temperature conditions, at varying plant ages, in the presence of specific metabolic poisons, and with plants whose roots had been killed by freezing or boiling. Depression of iodide absorption by cold becomes greater as plants become older. Transpiration from cold leaves almost ceases, while uptake of iodide is not similarly curtailed, especially in younger plants. The iodide is clearly not moving in conjunction with any general flow of water brought about by transpiration.

Gaseous I^{131} was absorbed more extensively by moistened plant leaves than by dry controls. Moistened filter paper absorbed a similarly increased amount when compared with a dry control. On the other hand, wet soil accumulated no more I^{131} (and in some cases less) than did dry soil. It is possible that the wet soil exposed a smaller surface area on which the gaseous I^{131} could adsorb. This possibility is now being investigated.

Soil samples were taken at various depths from a plot contaminated ten years ago with Sr^{90} and not cultivated during the intervening time, except for

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some soil disturbance associated with weeding and surface planting. The distribution of activity is shown in the following table:

Depth below surface in inches	% Sr^{90} in Zone
0	19.3 ± 6
1	21.7 ± 4
3	35.0 ± 10
6	14.7 ± 4
9	4.0 ± 3.0
12	1.8 ± 1.0

Columbia River Limnology

Because of high water only limited data are available for plankton and periphyton. Zinc-65 concentrations in plankton remained the same in May as in April; P^{32} and Sc^{46} decreased. Periphyton samples taken at the same time showed a decrease in mass per unit substrate but a two-fold increase of P^{32} and Zn^{65} per unit substrate; Sc^{46} remained approximately the same.

R. Thompson

Acting Manager
BIOLOGY LABORATORY

RC Thompson:es

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TECHNICAL INTERCHANGE DATA
BIOLOGY LABORATORY

I. Speeches Presented

a. Papers Presented at Society Meetings and Symposia

Bair, W. J. Effect of the form of inhaled cerium dioxide on its removal by diethylenetriamine-pentaacetic acid. Health Physics Society Meeting, Cincinnati, Ohio. June 15-18, 1964.

Keough, R. F. Flame spectrophotometric determination of calcium after strontium oxalate coprecipitation. American Chemical Society, Spokane, Washington. June 15, 1964.

Cline, J. F. Effect of climatic, physical, and biological conditions on deposition and retention of I^{131} on plants. American Society of Plant Physiologists, A.A.A.S. Western Section, University of British Columbia, Vancouver, B.C. June 22-25, 1964.

b. Seminars (Off-Site and Local)

McClellan, R. O. Radiostrontium metabolism and toxicity in miniature swine. University of Oregon Dental School, Portland, Oregon. June 4, 1964.

Mahlum, D. D. Cellular effects of radiation. Biochemical effects of radiation. University of Washington Summer Institute, Seattle, Washington. June 21, 1964.

Hungate, F. P. Genetics. University of Washington Summer Institute, Seattle, Washington, June 26, 1964.

c. Seminars (Biology)

Dr. Herta Spencer, Chief, Metabolic Section, Veteran's Administration, Edward Hines, Jr. Hospital, Hines, Illinois. Radiostrontium metabolism in man. June 22, 1964.

William R. Wiley, Department of Bacteriology and Public Health, Washington State University, Pullman, Washington. The requirements of an alkaline pH and NH_4 ions for membrane transport by Bacillus pasteurii. June 29, 1964

d. Miscellaneous

None

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II. Articles Published

a. HW Documents

Hanford Biology Research Annual Report for 1963. Unclassified. HW-80500. January 15, 1964.

b. Open Literature

Clarke, W. J. and W. J. Bair. Plutonium inhalation studies. VI. Pathologic effects of inhaled plutonium particles in dogs. Health Physics 10, No. 6: 391-398 (1964).

Rickard, W. H. Spring precipitation and the strontium-90 contamination of wheat in the semi-arid regions of Idaho and Montana. Nature 201: 309-310 (1964).

III. Visits and Visitors

a. Visits to Hanford

Bryce Allred of E. R. Squibb and Sons, Bellevue, Washington visited facilities and discussed research with L. K. Bustad. June 3, 1964.

Twenty members of the Sunnyside, Washington Chamber of Commerce toured facilities with R. F. Palmer and J. F. Cline on June 5, 1964.

H. L. Corson and A. W. Lade, retired GE employees, toured facilities on June 2, 1964.

Dr. B. A. Butt and associates from Department of Agriculture Entomology Branch, Yakima, Washington, toured facilities with F. P. Hungate. June 9, 1964.

Admiral Walters and associates of the USN, Washington, D.C. toured Biology facilities. June 10, 1964.

Dwight Allen and Richard Damon of Stanford University and A. E. Lind Superintendent of Richland Schools, toured facilities and discussed research with FP Hungate and LK Bustad. June 18, 1964.

Neal W. Clapp, Department of Radiology and Radiation Biology, Colorado State University, Ft. Collins, Colo. toured facilities. June 19.

Jerome C. Pekas, UT-AEC Project, Oak Ridge, Tennessee, visited facilities. June 23, 1964.

Dr. Herta Spencer, Chief, Metabolic Section, Edward Hines Hospital, Hines, Illinois, toured and presented a seminar. June 22, 1964.

W. R. Wiley and A. Johnson, Washington State University, Pullman, presented a seminar and toured facilities. June 29-30, 1964.

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b. Visits Off-site

6/3-4 - V. G. Horstman discussed research with Drs. Weaver and Rogers at the Univ. of Oregon Dental and Medical Schools in Portland.

6/3-4 - R. O. McClellan discussed research with Dr. Weaver and presented a seminar at the University of Oregon Dental School in Portland.

6/4 - W. H. Rickard and L. L. Eberhardt collected fallout samples in the Blue Mountains.

6/7-12 - J. Hsieh attended the Symposium on Surface Contamination in Gatlinsburg, Tennessee.

6/8 - M. P. Fujihara collected blood samples at the State Fish Hatcheries in Yakima and Natches.

6/9 - V. G. Horstman transported two miniature swine to Geiger Air Field for shipment to SPAL Division of Pharm. Food and Drug Administration, Washington, D.C.

6/14-15 - R. F. Keough presented paper at the Northwest Regional Meeting of the American Chemical Society in Spokane, Wash.

6/14-15 - V. H. Smith attended the Northwest Regional American Chemical Society Meeting in Spokane, Wash.

6/14-20 - H. A. Ragan presented a paper at the Health Physics Society Meeting in Cincinnati, Ohio and discussed research and visited facilities at UT-AEC Project, Oak Ridge, Tenn.

6/15-19 - W. J. Bair presented a paper at the Health Physics Society Meeting in Cincinnati, and visited animal facilities at Ohio State University Veterinary School in Columbus.

6/15-16 - R. E. Nakatani discussed research at the University of Washington Laboratory of Radiation Biology in Seattle.

6/15-18 - J. M. Dean attended a symposium and discussed research at the Steinhart Aquarium in San Francisco and the University of California at Berkeley. (Symposium held at Berkeley)

6/15-19 - J. E. Ballou attended the Health Physics Society Meeting in Cincinnati, Ohio. and discussed research with JN Stannard at the University of Rochester, Rochester, N.Y.

6/15-22 - R. C. Thompson attended the Health Physics Meeting in Cincinnati, Ohio, discussed research and interviewed J. K. Gong at the Hospital of Special Surgery in New York and attended the NCRP Meeting in New York.

6/21 - D. D. Mahlum presented lectures at the University of Washington.

6/22 - V. G. Horstman inspected feed and collected samples at the Pendleton Grain Growers in Hermiston, Oregon.

6/22-26 - L. L. Eberhardt, C. E. Cushing, J. F. Cline, and D. O. Wilson attended the Pacific Division, Western Section of the A.A.A.S. Meetings in Vancouver, B.C. Paper presented by Cline.

6/25-26 - F. P. Hungate and D. G. Watson attended a Meeting on Columbia River Studies at University of Washington. Hungate also presented a lecture at the Summer Institute.

6/27-30 - L. K. Bustad presented a lecture at the Summer Institute.

6/27-9/15 - W. C. Hanson conducting biological studies in Alaska.

6/30 - M. P. Fujihara picked up fish at the State Fish Hatchery in Natches.

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IV. Achievements

None

V. Honors and Recognitions

None

VI. Professional Group or Organization Assignments

None

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APPLIED MATHEMATICS OPERATION
MONTHLY REPORT - JUNE, 1964

ORGANIZATION AND PERSONNEL

Professor J. L. Sanders from the University of Arizona joined the group on June 4 as a summer professor.
J. A. Weed reported for work as a statistician on June 22.
H. D. Huber returned to work on June 22 after an extended illness leave.
P. P. Rowe terminated on June 15 to take an academic position.

ACTIVITIES FOR OTHER HAPO COMPONENTS

N-Reactor Department

An experiment relative to the optical comparator was designed and analyzed.

Irradiation Processing Department

Production Fuels

The patterns for placing fuel elements in reactor tubes were determined for personnel interested in comparing treatments resulting from a 2X3 factorial test. The fuel elements were oil or water-quenched and were α-annealed, pre AlSi dipped or received regular canning treatment.

A series of tests to determine the effects of can-sleeve pre-heat time and total submerge time in canning four different fuel element types have been analyzed and reported. The yield variables are the external and internal UE-1 and UT-4 bond integrity measurements.

Assistance has been given in the methods of analyzing data resulting from the program of sampling safety climate.

Research and Engineering

A design for a production test comparing 12 treatments was prepared for personnel interested in investigating the dimensional distortion performance of depleted uranium fuel elements in the reactor. The design used the property that the sequential placing of columns from a latin square will eliminate the effects of a linear gradient which in this instance is the radiation effect on warp. An example of how the data from this test should be analyzed is being prepared.

Irradiation Processing Department (Continued)

Two independent requests were received for studies of the reliability of the meter relays in the zone temperature monitoring system. The relationship between the individual meter relay reliability and the system reliability is being studied. Results have also been determined which relate past meter relay performance with the probability of failure to detect a scram incident.

Work is continuing on PT-572 to characterize weight loss and dimensional distortion effects according to support heights of self-supported fuel elements.

Assistance has been given in the analysis of R value results, where the R is a measure of circumferential temperature imbalance in the water leaving process tubes.

The IPD Fuels Maintenance Operation will use the 100 B-C preventive maintenance system excluding the production support part. This will enable them to become familiar with the basic system before attempting to incorporate their own rather complex production support activities.

Information Systems work continues. The 100 B-C preventive maintenance system was run covering 1964. Individual craftsmen job cards were generated for the first six months and sent to the appropriate Maintenance Management. Various data and classification errors were caught and are being corrected. The system should now be on-line for the scheduling portion unless the corrected data are again found faulty.

Chemical Processing Department

An examination of the reliability of fission product recovery sampling and analytical measurements is being made. A non-orthogonal analysis of variance was made to determine sources of variability in measurement of isotopic mass ratios.

Business Planning and Transfer Operation

The AEC is about to launch a full scale study of the impact of its facilities on the national economy. As a consequence there will be a study of the Tri-City Area. At the request of RLOO, work has begun analyzing the elaborate AEC questionaire and planning the required survey. The formal request to undertake that study would be received early in July, and the report requested by the end of September.

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Contract and Accounting Operation

The most recent version of the Linear Program LP/90 as distributed by SHARE has been made compatible with HAPO EDP equipment, and has been successfully employed by IPD personnel.

Assistance was given to Nuclear Materials Measurements personnel in the construction of the first level matrix for Z plant's nuclear materials measurement system.

ACTIVITIES WITHIN HANFORD LABORATORIES

2000 Program

C Column Computer Control

Work continued on programming for the GE 412 Process Control Computer which will be used to control the operation of the C column. Eight of eleven functional programs have now been specified. Documentation of these completed programs is still in progress.

3000 Program

Consultation services were provided Plutonium Fabrication Development Operation on problems concerned with flow of molten materials.

4000 Program

Sonic Transmission in Visco-elastic materials

An EDPM program is being assembled which evaluates the pulse shape of rebounding ultrasonic waves from the plane boundary between two distinct infinite media. This analysis and computation employs a sound transmission model for which amplitude losses are assumed proportional to frequency.

Particle Packing Studies

Particle size and proportional mix factors were calculated for the fabrication of (1) a Calrod element containing an internal helical wire, (2) a fuel element of the type used in EBWR, and (3) an experimental non-circular control rod. Fabrications were attempted on (1) and (2) and were successfully completed.

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4000 Program (Continued)

Considerable progress was made on devising a mathematical model for the diffusion of oxygen into spherical particles of uranium under the assumption that uranium will react with oxygen at a rate proportional to the deviation of the oxygen concentration from a postulated fixed level.

Radiation Damage to Fissionable Material

The FORTRAN language program SALTY to unfold an observed two-dimensional particle size distribution into its three-dimensional counterpart was completely debugged. Documentation of the program is now in progress. The program, which is available to Laboratory people on request, uses Ziess particle size analyzer distributional data as input. The particle size distribution output is in the form of a histogram based on an arbitrary number of cells which are specified by the experimentor. Standard error estimates of the relative frequency in each cell of the histogram and correlation coefficients for the various cell frequencies are included in the output. In addition a log frequency-log diameter graph is printed out.

Program specifications for a 7090 Monte Carlo routine to assess directly the propagated errors of the mass spectrometer have been prepared.

5000 Program

Computation and Statistical Analysis

Work continued on the calculation of the power function of the Poisson index statistic used to check stability of counting instruments. Error calculations are in progress to make certain that the basic computational program has five figure accuracy. The uniformly most powerful similar region test of the null hypothesis that a set of random times between successive counts arose from the decay of a pure nuclide against the alternative hypothesis that the counts were generated from a uniform intensity background was completed. Power function calculations are in progress to determine the sensitivity of the test as a function of initial counting rate.

Actinide Element Research

The third goal of this phase of the program was achieved with the issuance of HW-89062 which documents the orthorhombic indexing program.

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6000 Program

Biology

A statistical analysis of adult progeny data from X-ray exposed Tribolium Castaneum was initiated. The purpose of the study is to investigate the effects different levels of X-ray exposure to one or both members of a mating pair and temperature have on the number of adult progeny produced.

An experimental design was outlined to measure the activity of a fish burdened with Zn^{65}.

The computer program for the Zn^{65} fish study file was revised to make it more flexible.

Work was started on exploring models of population interactions in support of ecological studies of post-attack situations. Work continues on a systems approach to the analysis of economic-biological interactions post nuclear attack.

A procedure leading to an estimate of the "safety margin" (bias) inherent in the present external dosimetry measurements was designed.

Work is continuing on the program of fitting density distributions to observed particle sizes.

Other

Two reports were completed by the HL Computer Task Force. These reports discuss tentative computer configurations suggested by several digital computer manufacturers and the current level of service provided to Hanford Laboratories by EDPO.

R. Y. Dean

Acting Manager
APPLIED MATHEMATICS

RY Dean:bsh

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PROGRAMMING

REACTOR PROGRAM - 04 PROGRAM

PLUTONIUM UTILIZATION PROGRAM

Small Production Reactor Simulation

In further investigation of converting the small Hanford production reactors to power reactors, a new lattice cell was examined. This cell was based on the present lattice configuration, but with one-half of the graphite removed from the graphite stringer through which the process tube passes. Removal of this graphite would serve the dual purpose of providing steam venting in the event of a process tube failure, and reducing the amount of moderation in the unit cell. This lattice was examined using the JASON-MELEAGER chain program. To account for the void in the lattice, the effective density of the graphite was reduced. This approach had the effect of "smearing" the void throughout the large moderating region.

Table I shows the fuel costs obtained with this cell compared with the standard configuration. In the case of metallic uranium fuel, lower fuel costs are obtained because the removal of the graphite increases the fertility of the uranium fuel. The spectrum is hardened slightly and there is more *in situ* burning of the plutonium that is formed.

The spatial concentration of fuel in the lattice is varied as noted in the first column of Table I, Fraction of Theoretical (fuel) Density. This parametric variation is made because metallic uranium probably will not be durable at exposures of 8000 Mwd/ton, but an alloy or matrix fuel may be adequately durable. The fuel exposures in Table I are listed in Mwd/ton of heavy isotopes in the fuel (i.e., essentially per ton of fertile plus fissile content). Thus, at an exposure of 15,000 Mwd/ton at 0.4 density, a cubic centimeter of fuel generates the same amount of heat as does fuel at full density at an exposure of 6000 Mwd/ton.

Code Development

Economic comparisons of seed-blanket reactors in which the blanket regions have been driven with one, two, or more successive seeds have required computation of the complete history of each reactor. ALTHAEA was revised to place the blanket data on tape each time a seed region reaches terminal exposure; and, now, histories of all the reactors are available even though only the one with the greatest number of seeds was actually calculated. A new code known as the SEED-BLANKET EDITOR has been written, debugged, and placed on the ECONOMICS CHAIN master tape as Link 6. This code reads the B8 tape written by ALTHAEA, extracts the intermediate data, and writes the expanded histories of several reactors on B7 in a form suitable for the QUICK Economics code. A typical problem, which would have taken 55 minutes on the 7090 computer now requires 20 minutes.

TABLE I

SLIGHTLY-ENRICHED METALLIC URANIUM FUEL
$5/lb FEFJ $2/lb SEPARATIVE COST

Fraction of Theoretical Density	New Cell			Standard Cell		
	MTFC* (Mills/ Kwh_e)	Enriched (%)	Exposure (Mwd/ton)	MTFC* (Mills/ Kwh_e)	Enriched (%)	Exposure (Mwd/ton)
1.0	0.322	0.705	8,697	0.434	0.713	8,104
0.8	0.448	0.746	8,673	0.607	0.946	13,149
0.6	0.635	0.906	10,991	0.726	0.950	11,266
0.4	0.917	1.233	15,072	1.002	1.303	15,376
SLIGHTLY-ENRICHED URANIUM OXIDE FUEL $30/lb FEFJ $10/lb SEPARATIVE COST						
1.0	1.340	1.513	21,480	1.453	1.440	18,842
0.8	1.560	1.925	26,123	1.554	1.683	22,156
0.6	1.750	2.510	31,833	1.825	3.000	36,883
0.4	2.130	2.82	32,854	2.129	3.770	42,700

*Minimized total fuel cost.

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The seed-blanket reactor control system, described by A. Radkowsky involves the use of a fixed amount of seed (occupying ~20% of the reactor volume) one-half of which is fixed and one-half of which is movable. In the high reactivity position, the two portions of the seed are adjacent and the flux is allowed to peak in the seed, while in the low reactivity position, each portion of the seed is surrounded by blanket and flux peaking in the seed is less. A new control computation has been added to ALTHAEA which alters the leakage from the seed region to the blanket region and changes the flux peaking in the seed by adjusting the diffusion coefficients. Computations are in progress to evaluate this simulation of variable geometry.

The SUPERCASE GENERATOR code, used to generate parameters for reactor burn up, has been modified for use with the plutonium recycle chain system. The code is fixed so that the programmer may determine whether it is used normally or in conjunction with the recycle system.

The values of enrichment for which reactor burn ups are to be run are determined by CHECKER, a subroutine of SUPERCASE GENERATOR. The manner in which CHECKER was originally programmed to select enrichment values usually resulted in a larger number of long exposures than short exposures. This function of CHECKER has been changed so that the burn ups can be more evenly distributed over a chosen range of enrichments; the distribution is largely determined by the programmer.

VESTA - Fuel Utilization Code (formerly YUKON code)

The VESTA code is being revised to allow a "pecking order," or priority, for allocation of the plutonium available at any time. For example, the plutonium can be used to feed fast reactor inventory as rapidly as possible. If the plutonium available at any time is in excess of the requirements of fast reactors, excess can be used for recycle. However, if a different pecking order is desired, then some plutonium can first be used for partial recycle and the remainder used to feed fast reactors.

In conjunction with running VESTA studies, the advanced design of the 1000 Mw_e PWR has been simulated for various amounts of both plutonium recycle and uranium ore prices for use as input data to VESTA. Also, as a convenience in running these studies, the Conservation program(1) has been added as a link of the chain.

The fuel cost code QUICK is also being altered to compute fuel exposures in terms of metric and British units. The jacketing and separations costs can be entered with fixed and variable components. A fixed and variable cost can be derived for recovery of special products such as decay heat isotopes. The PROTEUS cost code which converts zero-dimensional MELEAGER data into approximate one-dimensional form to simulate the graded cycle has been altered for limitations in the number of possible fuel movements during a fuel element lifetime.

(1) M. F. Kanninen, "Fuel Conservation in Thermal Reactors", HW-79287-RD

Nuclear Health and Safety

The Preliminary Safeguards Analysis, High Temperature Lattice Test Reactor, HW-82372, was issued and transmitted to the Richland Operations Office of the AEC for review. At the request of the AEC, members of the Hanford Laboratories staff met in Washington for an informal review with the Division of Reactor Development staff.

Agreement has been reached with the AEC on operating safety limits for the PRTR. These have been officially transmitted from the Richland Operations Office to General Electric in a document dated June 1, 1964.

F. W. Woodfield
Manager-Programming

FW Woodfield:bwc

1237408

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF JUNE 1964

A. ORGANIZATION AND PERSONNEL

D. C. Carl, formerly of Internal Dosimetry, terminated June 26. P. L. Sheldon transferred from Internal Dosimetry to Biology effective June 8. R. L. Farber transferred to Internal Dosimetry from Technical Information effective June 4. H. J. Paas, Jr., Radiological Development and Calibrations, terminated June 3. Tech Grad R. W. Hardie accepted rotational assignment in RDCO. I. W. White terminated from External Dosimetry June 26. R. C. Lawrence transferred from Environmental Studies and Evaluation to Reactor Metals Research effective June 15. Alice L. Didier, Secretary, Radiation Protection, terminated June 12. Nadene Ped filled the vacancy.

B. ACTIVITIES

Occupational Exposure Experience

There were no new plutonium cases confirmed by special bioassay analysis during the month. The total number of individuals who have received internal plutonium depositions at Hanford is 344. With the reactivation of one employee and the termination of three other employees having confirmed plutonium depositions, there are currently 245 employed at Hanford.

In June there were eight incidents involving fifteen employees which required special bioassay sampling for plutonium analysis. The following are brief descriptions of the more significant incidents:

A CPD maintenance employee received a cut on his right index finger while working with a steel cable in a hood in the Plutonium Purification and Fabrication Building (234-5). No contamination could be detected on the surface of the wound and an examination, using the plutonium wound counter, indicated less than the detection level of 1×10^{-4} μCi at the wound site.

Two CPD employees were exposed to high air-borne concentrations of plutonium when a fire occurred in a dissolving hood in the Plutonium Purification and Fabrication Building (234-5). One employee received extensive skin contamination of 20,000 to 40,000 d/m and nasal contamination as indicated by smears of 3000 and 4200 d/m. The second person received contamination

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up to 1000 d/m on the face and hair and nasal contamination indicated by smears of 600 and 800 d/m. Both employees were decontaminated before going home.

A CPD pipefitter received skin contamination in excess of 4×10^6 d/m on the middle finger, left hand when a hood glove ruptured while working with plutonium fluoride in the Plutonium Purification and Fabrication Building (234-5). The contamination was immediately reduced to less than detectable levels.

A CPD operator received a puncture wound on his right thumb on 6-16-64 while working at a leaching hood in the Plutonium Purification and Fabrication Building (234-5). Contamination of 5000 d/m at the wound site was reduced to 1000 d/m. Examination of the thumb, using the plutonium wound counter, indicated 3×10^{-4} μCi. The employee is a previous deposition case of ≈1% of the maximum permissible body burden (MPBB plutonium with bone as a reference is 0.04 μCi).

A CPD utility operator received a puncture wound on the palm of his right hand on 6-19-64 while working in the Incineration Building (232-Z). External contamination at the wound site was removed immediately. An examination of the palm, using the plutonium wound counter, indicated 2×10^{-3} μCi. After excision at GE First Aid Station, a recount indicated less than the detection limit of 1×10^{-4} μCi. The employee is not a previous deposition case.

Six CPD employees received extensive skin contamination up to 40,000 d/m plutonium while changing a process exhaust filter in the Plutonium Purification and Fabrication Building (234-5). Nasal contamination was indicated by smears up to 3000 d/m. All employees were successfully decontaminated.

In addition to the incidents involving plutonium, there were four incidents involving nine persons that required evaluation for possible intake of other radioisotopes. None of these incidents resulted in any significant deposition.

There was one incident of special interest involving exposure to an employee from an external radiation source. Protective clothing worn by a CPD laboratory employee for a period up to one hour was later found contaminated. The dose to a localized skin area, based on a film study of the coveralls and a one-hour exposure period, was 70 rads, including 0.5 Roentgens.

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Environmental Experience

The two swamps that receive process cooling water from the Purex Plant became contaminated on June 12, as a result of the failure of a cooling coil in a concentrated waste sampling tank F-15. Current estimates indicate that some 10,000 curies, primarily Zr-Nb^{95}, $Ce^{141-144}$, and Ru^{103}, entered the swamps. The radioactivity has remained in the swamps and access to the swamps has been controlled to limit exposure to personnel. New ditches leading to the swamps are being excavated and the contamination in the old ditches covered with backfill. Transient waterfowl that might carry the contamination off-project are not migrating through the area at this season, and control measures to prevent their contamination should be completed before the flights arrive.

The emission rates of filterable gross beta materials from the Purex Plant stack increased during the last week of the month to 0.1 to 0.5 Ci per day. The normal filterable gross beta material emission rate is 10^{-3} to 10^{-2} Ci per day. The current rates will not result in significant environmental contamination.

The average concentrations of fallout materials in the air of the Pacific Northwest was 1.9 p Ci β/m^3 -- not significantly different from last month.

Studies and Improvements

A summary of the internal dosimetry aspects of handling Am^{241} was prepared. Briefly, the following points were made:

1. Am^{241} behaves biologically similar to plutonium.

2. Because of its substantially higher specific activity it is, on a gram-for-gram basis, about 40 times as radiotoxic as plutonium, thus making it one of the most radiotoxic materials ever to be produced in any significant quantity at Hanford.

3. Due to the high specific activity and rather high solution concentrations likely to be encountered, contaminated injuries are potentially very serious.

4. Air contamination following a spill, particularly of a dry Am^{241} powder, could be exceedingly high (about 50 times as high as an equivalent weight amount of plutonium), thus posing a severe inhalation hazard.

Routine bioassay schedules were established for all personnel involved in americium processing.

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An experiment was designed to measure a number of important parameters in the plutonium urinalysis techniques. These include:

1. Degree of correlation of results obtained using the rapid analysis technique with that obtained using the standard electrodeposition and autoradiography analysis technique.

2. Yields obtained by both methods.

3. Reproducibility of both methods.

4. Correlation between counting results utilizing the low background gas proportional alpha counters, and with the same samples counted by alpha track microscopy techniques.

Radiological Physics Operation turned over the new phosphorous-32 beta counter to IDO during the month.

Two new plutonium wound counters were built using a new type photomultiplier tube. These counters are superior to the older wound counters because of the lower voltage which can be used and the higher gain. Efficiencies were measured at ~19%, as compared to ~15% for the old counters.

The ventilation system for Project CAH-119 - PRTR Storage Basin and Experimental Facilities Modification was reviewed on several occasions. The design progressed through several major changes before general agreement was reached. Basically, the system is a conventional chilled air supply exhausted through high efficiency filters and through the existing PRTR stack. Ten air changes per hour was specified as the minimum acceptable for the facility.

The behavior of portable radiation monitoring instruments when exposed to 0.1 μsec duration Flash X-ray radiation pulses was studied. The instruments examined to date, CP, TPC, HPC and Juno gave a full scale meter deflection immediately following the radiation burst. The meters remained in the full scale position for times varying from several seconds to nearly 30 seconds. In the tests completed to date, integrated doses of 1 R and 25 mR were used. The test program will be continued until the performance of all instruments is determined. A complete report of the response will be prepared.

The air samples collected on HV-70 filter paper and counted with the surface barrier detector were analyzed for total plutonium content by

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the Analytical Laboratories. This accurate analysis of actual plutonium content can be used to determine the correction factors necessary to determine plutonium air sample concentrations when utilizing the surface barrier detector. The detector used showed about a 36 per cent geometry when counting plutonium plated on a stainless steel disk. Using the laboratory analysis for the air samples, the detector showed 17 to 20 per cent geometry for the six samples; the difference being a combination of the backscatter from the stainless plate and the self-absorption of the filter material.

Several neutron exposures completed in April were read to determine the dose retention properties of the thermoluminescent dosimeters (TLD's). The dosimeters that showed a positive result had a sensitivity of about 0.5 reader units per rad, essentially the same as previously reported for dosimeters read immediately after exposure. These dosimeters were held about six weeks before readout. Several sets of TLD's exposed to 50 mrads did not yield a positive result. The dosimeters in this test were all 50 mg samples of Li^7F.

Several new fission foils suitable for use with the fission fragment neutron detector were prepared by Plutonium Metallurgy. These samples provided natural and 95% enriched uranium oxide permanently bonded with a resinous material to prevent contamination spread. Foils containing uranium to about 80 mg/cm^2 gave the best results. Accelerator tests at neutron energies between 0.25 Mev and 1.4 Mev indicated that 95% uranium-235 foils produced about one track per optical field of view for a dose of 0.1 rads.

The 300 Area Emergency Plan was revised to reflect changes in policy and to clarify emergency action to be taken by personnel in the 300 Area in the event of a serious accident.

All exposure records for GE employees from the start of the plant to January 1, 1964 have been microfilmed and placed in individual microfilm jackets. This represents at least 20,000 individual employee records.

Research Studies

Effect of Reactor Effluent on the Quality of Columbia River Water (02)

The flow of the river was substantially higher this month than at any other time since this study began. Temperature traverses were, therefore, repeated at selected locations to develop data on the variations in temperature that exist across the river at such high flow rates and greater widths. Additional measurements were also obtained on the temperatures within the effluent "bubbles" and plumes.

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Mechanisms of Environmental Exposure (02)

Work continued on the preparation of a data file that will allow EDP correlation of whole body counting data with dietary information. About 2500 events will be included in the file and it is apparent that its use can be extended to numerous other studies that involve body burdens as measured by the whole body counters.

Preparations were begun for a study of the population that lives on farms irrigated with Columbia River water just upriver from Pasco. Volunteers from the selected population will be given whole body counts and asked to complete questionnaires in order to develop information on the use of water and foods, and metabolic data on Zn^{65}.

Nuclear Facility Monitoring Guide (04)

In order to obtain firsthand information on the effluent monitoring programs now in place at representative power reactors, five such facilities in the U. S. were visited. The experience gained thus far at these facilities provides valuable guidance that will be incorporated into the manual.

C. RELATIONS

There were no minor injuries and no security violations during the month.

Two suggestions were received and three suggestions evaluated and adopted. Four suggestions remain outstanding.

Training talks on exposure standards, operational controls, and radiation protection practices were presented to several groups throughout the month. A training bulletin on the physical and biological properties of tritium and the routine tritium monitoring program was prepared and distributed to PRTR radiation monitoring personnel.

Refresher course training in emergency monitoring was conducted for personnel at the Central and the 200 West Area Fire Stations. Radiation protection orientation lectures were presented to new personnel of the various Hanford components.

D. SIGNIFICANT REPORTS

HW-SA-3318 - "Environmental Evaluation of An Acute Release of I-131 to the Atmosphere" by J. K. Soldat, June 10, 1964, presented at the Health Physics Society Meeting, June 15-18, Cincinnati, Ohio.

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HW-SA-3517 - "Interpretation of Whole Body Counter and Bioassay Data in Assessment of Environmental Radiation Exposure" by I. C. Nelson and R. F. Foster, June 18, 1964, presented at the Health Physics Society Meeting, June 15-18, Cincinnati, Ohio.

HW-SA-3525 - "Neutron Spectrum Measurements at Hanford Work Locations" by G. W. R. Endres, May 15, 1964, presented at the Health Physics Society Meeting, June 15-18, Cincinnati, Ohio.

HW-SA-3526 - "The Status of New Personnel Neutron Dosimetry Development" by C. M. Unruh, May 15, 1964, presented at the Health Physics Society Meeting, June 15-18, Cincinnati, Ohio.

HW-SA-3559 - "The Hanford Mobile Whole Body Counter" by D. N. Brady and F. Swanberg, June 1, 1964, presented at the Health Physics Society Meeting, June 15-18, Cincinnati, Ohio.

HW-82705 - "A Review of the Air Monitoring Program at the PRTR" by D. McConnon and K. B. Turner, May 15, 1964.

HW-80892 5 - "Radiological Status of the Hanford Environs for May, 1964" by R. F. Foster, June 16, 1964.

External Exposure Above Permissible Limits	Current Month	Year to Date
Whole Body Penetrating	1	3
Whole Body Skin	0	1
Extremity	0	1
Hanford Pocket Dosimeters		
Dosimeters Processed	7,558	28,140
Hanford Beta-gamma Film Badge Dosimeters		
Film Processed	3,846	52,657
Results - 100-300 mrads	123	881
Results - 300-500 mrads	14	102
Results - Over 500 mrads	11	38
Lost Results	2	39
Average Dose Per Film Packet - mrad (ow)	13.2	7.5
mr (s)	7.5	42.2
Hanford Film Badge Dosimeters		
Slow Neutron		
Film Processed	264	4,044
Results - 50-100 mrem	1	25
Results - 100-300 mrem	0	29
Results - Over 300 mrem	0	5
Lost Readings	0	5
Fast Neutron		
Film Processed	1,321	3,680
Results - 50-100 mrem	31	95
Results - 100-300 mrem	68	256
Results - Over 300 mrem	0	4
Lost Results	0	3
Hand Checks		
Checks Taken - alpha	41,744	224,301
beta-gamma	62,941	338,009
Skin Contamination		
Plutonium	45	138
Fission Products	49	304
Uranium	0	8
Tritium	0	0
Thorium	0	0

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Whole Body Counter

Subject	Number of Examinations			
	747-A WBC	1964	Mobile WBC	1964
GE Employees				
Regular	63	253	58	568
Incident Cases	6	62	2	7
Terminations	51	107	0	0
New Hires	91	195	0	0
Special Studies	16	53	0	10
Non-Employees	0	21	0	0
Total	227	691	60	585

Bioassay

Analysis	Current Reporting Limit	Results Above Reporting Limit		Samples Assayed	
		June	1964	June	1964
Plutonium	2.2×10^{-8} µc/sam	63	455	517	3354
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	419	1204	504	1714
Uranium	0.14 ugm/l	0	0	174	1032
Special Studies		0	0	0	164

Calibrations

	Number of Units Calibrated	
Portable Instruments	June	1964
CP Meter	1124	6543
Juno	273	1612
GM	521	3160
Other	238	1429
Audits	104	627
Total	2260	13,371
Personnel Meters		
Beta-gamma film	1632	5354
Rings	45	480
Other film	516	1806
Total	2193	7,640
Miscellaneous Special Services	125	1,147
Total Number of Calibrations	4578	22,158

Environmental Monitoring

Samples	June	1964
Air		
Filters	347	2040
Scrubbers	288	1455
Water		
Raw	55	262
Sanitary	104	508
Process	25	140
Vegetation	158	643
Test Wells	232	1570
Fish	147	726
Food Products	73	296
Beef Thyroids	56	265
Waterfowl	19	96
Measurements		
Control Plots	58	341
Aerial Monitoring	2	10
Ionization Chambers	205	1390

AR Keene

Manager
RADIATION PROTECTION

AR Keene:CMU:np

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FINANCE AND ADMINISTRATION

ACCOUNTING

Cost Accounting

The Hanford Laboratories' operating budget was adjusted during the month to reflect changes in the AEC Financial Plan, transfers between HAPO components, and the carry-over of funds on off-site work to FY 1965. The program adjustments are as follows:

(Dollars in thousands)	Previous Budget	Increase (Decrease)	New Budget
02 Program			
HL Plutonium Nuclear Safety	$ 538	$ (20)	$ 518
IPD Sponsored Reactor Program	335	16	351
04 Program			
Irradiation Damage to Reactor Metals	1 637	(6)	1 631
Nuclear Facility Monitoring Guide	20	(8)	12
Fueled Graphite Studies	220	(66)	154
Waste Solidification Engineering Prototype	673	40	713
07 Program			
Major Conference Displays	--	17	17
Off-Site Work			
NASA Programs	1 025	(110)	915
AEC-AECL Cooperative Program	134	(26)	108

The Hanford Laboratories' booklet entitled, "Summary of Budget for FY 1966 and Revision of Budget for FY 1965" was published in June.

An increase of $40,000 for Miscellaneous Capital Work Orders was authorized for Hanford Laboratories in June, increasing the total FY 1964 allocation to $407,000.

A special accounting code was established during June for the activity described below:

.2H - Densification of MgO and UO_2 by Penumatic Compaction for APED - costs are estimated at $1,185 for this job utilizing the Dynapak equipment.

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General Accounting

All working copies of Contract AT(45-1)-1350 in the hands of Hanford Laboratories' personnel were recalled and returned to Contract and Accounting Operation. New copies, incorporating all changes to date, including Supplement 2 effective July 1, 1964, were issued to the Manager-Hanford Laboratories, the Manager-Finance and Administration, and the Manager-General Accounting. Copies of Appendix "B" are now held by the above and by the Specialist-Personnel Accounting.

Following is the status of letters requesting AEC concurrence in proposed actions:

AT-347	Participation in Standardizing Activities - American Society for Testing and Materials - Task Group E-2/VI - Roy Ko	Approved 6-5-64
AT-348	Panel of Experts - Food and Agriculture Organization of the United Nations - R. F. Foster	Approved 6-4-64

The following revised OPGs were issued during the month of June 1964:

OPG No.	Title
22.3.1	Approval Authorizations
3.1.8	Suggestion Plan
7.5	Reporting Violations of Federal or AEC Security Regulations

Hanford Laboratories' net material investment at June 1, 1964 totaled $28.9 million as detailed below:

			(In thousands)
SS Material			$27 383
Reactor & Other Special Materials			1 269
Spare Parts			353
Yttrium			26
Subtotal			29 031
Reserve:	Spare Parts	$87	
	Yttrium	26	(113)
Net Inventory Investment			$28 918

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The cumulative value of nuclear material consumed in research by Hanford Laboratories during FY 1964 (at June 1, 1964) is as follows:

02 Program	$ 84 679
03 Program	291 519
04 Program	482 844
Total	$859 042

The status of Hanford Laboratories' heavy water inventory at June 30, 1964 is as follows:

	Current Month		FY to Date	
	Pounds	Value	Pounds	Value
Beginning balance	53 683	$ 717 601	29 774	$ 400 600
Acquisitions			54 890	755 988
Scrap returns	(20 611)	(256 234)	(39 702)	(497 174)
Consumptions -1)				
PRTR: Loss	(700)	(9 681)	(12 310)	(169 753)
Scrap		(4 966)		(38 514)
PRCF: Loss			(245)	(3 369)
Scrap				(574)
All Others: Loss			(35)	(484)
Ending balance	32 372	$ 446 720	32 372	$ 446 720 -2)

(1- Consumption - scrap reflects amount charged to operating cost only.

(2- Includes 2,776 pounds of heavy water scrap valued at $32,822.

A billing was submitted to Savannah River Operations Office for the June 22 shipment of heavy water consisting of 20,611 pounds with a fund value of $256,234 and a nonfund value of $127,266.

Certification inventory reports for the physical inventory of Reactor and Other Special Materials for the period ending June 30, 1964 were prepared and submitted to material holders for completion and certification. Upon receipt of the requested information and reconciliation with inventory records, a report of results will be issued.

Unitization reports were prepared and issued on the following projects:

CAH-958	Plutonium Fuels Testing and Evaluation Laboratory - 308 Building	$129 830
CGH-992	Additional Fuel Loading Equipment - 308 Building	170 790
CAH-995	Air Conditioning Modification - 309 Building	52 107
		$352 727

Laboratory Storage Pool activity is summarized as follows:

	Current Month		FY to Date	
	Quantity	Value	Quantity	Value
Beginning balance	1 858	$1 522 499	1 480	$ 811 520
Items received	409	173 488	2 354	1 486 147
Items reclaimed by custodians	(90)	(41 696)	(289)	(135 415)
Equipment transfers	(33)	(11 073)	(374)	(154 783)
Items disposed of by PDR	(34)	(43 096)	(210)	(56 360)
Items disposed of by excessing	(83)	(106 551)	(934)	(457 538)
Ending balance	2 027	$1 493 571	2 027	$1 493 571 -1)

(1- Includes 184 items valued at $116,669 on loan at June 30, 1964.

Loans & Transfers in Lieu of Purchases	Current Month		FY to Date	
	Quantity	Value	Quantity	Value
Loans	191	$ 89 011	1 214	$ 515 601
Transfers	33	11 073	374	154 783
Total	224	$ 100 084	1 588	$ 670 384
Operating Costs (5-31-64)		$ 1 165		$ 15 799

The value of loans and transfers from the Laboratory Storage Pool in lieu of purchases, less operating costs, since inception is as follows:

FY 1960	$ 6 673
FY 1961	66 204
FY 1962	95 957
FY 1963	185 185
FY 1964	653 620
Total	$1 007 639
Total building investment in the Pool facility:	$ 132 273

The value of material and equipment in custody of the Laboratory Storage Pool at June 30, 1964 totaled $2.5 million as detailed on the following page:

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Equipment	$1 493 571
Reactor & Other Special Materials	329 882
SS Materials	154 800
Other Materials	481 076
Total	$2 459 329

A Construction Completion and Cost Closing report was issued on Project CGH-999, Plutonium Recycle Critical Facility Conversion to Light Water.

The following contracts were processed during the month:

CA -447	E. C. Lingafelter
DDR-110 Suppl.	Battelle Memorial Institute
DDR-188	Precision Welder and Flexopress Corporation
SA -352	Ganders' Aircraft Repair
SA -353	Penberthy Electromelt Company

Personnel Accounting

The following patent awards were made during June:

J. J. Hauth) C. H. Bloomster) D. F. Carroll) L. E. Mills)	HWIR 1644	"Hot Wire" Heterogeneous Enrichment of Ceramic Fuel Elements.
D. W. Brite) K. R. Sump)	HWIR 1616	Fabrication of Dispersions by High Energy Rate Impaction.
D. C. Worlton	HWIR 1522	A Method of Employing Sonic Vibrations to the N Fuel Closure Process.
L. A. Bray) F. P. Roberts)	HWIR 1658	Separation of Rare Earth from Cerium.
G. E. Benedict	HWIR 1607	Preparation of Certain Metal Oxides and Mixed Oxides by Electrodeposition from Molten Chloride Salt Solutions.
W. L. Bunch	HWIR 967	Taper Bored Shield Sleeves for Reactor Entries.

Personnel statistics follow:

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Employee Changes	Total	Exempt	Nonexempt
Employees at beginning of month	1 795	804	991
Additions and transfers in	68	42	26
Removals and transfers out	32	19	13
Employees on payroll at end of month	1 831	827	1 004

Overtime Payments During Month	June	May
Exempt	$ 7 084	$ 3 751
Nonexempt	35 023	22 371
Total	$ 42 107	$ 26 122

Gross Payroll Paid During Month		
Exempt	$ 810 453	$ 795 560
Nonexempt	747 970	584 109
Total	$1 558 423	$1 379 669

Participation in Employee Benefit Plans at Month End	June		May	
	Number	Percent	Number	Percent
Pension	1 676	99.3	1 627	99.6
Insurance Plan - Personal	403		392	
- Dependent	1 393	99.8	1 391	99.9
U. S. Savings Bonds				
Stock Bonus Plan	149	34.8	147	36.3
Savings Plan	68	3.7	69	3.8
Savings and Security Plan	1 226	87.6	1 232	88.4
Good Neighbor Fund	1 307	71.5	1 287	72.8

Insurance Claims	Number	Amount	Number	Amount
Employee Benefits				
Life Insurance	2	$35 329	0	$ -0-
Weekly Sickness & Accident	9	793	11	1 004
Comprehensive Medical	57	4 001	60	4 201
Dependent Benefits				
Comprehensive Medical	135	12 621	150	13 811
Total	203	$52 744	221	$19 016

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TECHNICAL ADMINISTRATION

Requisitions for 13 nonexempt employees were filled; 21 remain to be filled.

Suggestion Plan activity:

Suggestions received	29
Suggestions adopted	23
Suggestions rejected	20
Suggestions in process	98

Visitors Center activity:

June attendance	4 113
Average attendance per day open	147
Cumulative attendance since 6-13-62	71 921
Conducted groups	9 (totaling 149 people)

Celebration of the second anniversary of the Visitors Center June 12, 13, and 14, was highly successful - 1,404 people attended.

Plant tour activity:

	Number	Total People
General public relations tours	5	84
Special tours	2	22

Other

40,000 people visited the Richland booth at the Washington Community Festival in Seattle to which we furnished the manipulator, four display panels, and literature.

Overall recruiting results for June are as follows:

Offers extended	14
Offers accepted	13
Offers rejected	7
Added to roll	26

Advanced Degree - Eleven Ph.D. applicants visited HAPO for employment interviews. Seven offers were extended; five acceptances and five rejections were received. Five offers are currently open.

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BS/MS (Direct Placement) - Five offers were extended. Six acceptances and one rejection were received. There are no offers currently open.

BS/MS (Program) - Two offers were extended. Two offers were accepted and one rejected. Four offers are currently open.

Technical Graduate Program - Fourteen Technical Graduates were placed on permanent assignment. Fifteen new members were added to the roll and none terminated from the roll Current Program numbers 46.

FACILITIES ENGINEERING

At month end, Facilities Engineering Operation was responsible for 11 active projects having total authorized funds in the amount of $10,520,500. The total estimated cost of these projects is $11,308,500. Expenditures through May 31, 1964 were $3,495,665.

The following summarizes project activity in June:

Authorized projects at month end ---------- 11

New projects authorized ---------- 2
CAH-126, Waste Transport System
CAH-151, Office Addition - 308 Building

Projects completed ---------- 0

New projects submitted to the AEC in June ---------- 1
CAH-151, Office Addition - 308 Building

New projects awaiting AEC approval ---------- 3
CAH-114, Critical Mass Laboratory Addition
CAH-123, Laboratory Fire Protection System
CAH-146, Atmospheric Physics Building

Project proposals being prepared ---------- 3
Geological and Hydrological Wells - FY 1965
Variable Spectrum Test Reactor
Power Supply for High Power Welder

Project proposal returned unapproved ---------- 1
CAH-128, Heat Transfer Apparatus for Model Studies

The status of active projects follows:

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CAH-916 Fuels Recycle Pilot Plant

Construction is 59 percent complete compared to a scheduled 43 percent. Fire protection and sprinkling piping are being installed. Stainless steel liners are being placed in two vaults. Metal wall panels are being placed on the Cold Canyon walls. Ventilation ductwork is being installed. Electrical conduit is being run throughout the building. Concrete has been poured for about one-fourth of the Hot Pilot Cells. The prefabricated metal wall liner forms for the Metallurgy Cells are being set in place.

CAH-962 Low Level Radiochemistry Building

Construction is six percent complete and on schedule. Pouring of the basement walls and floor is about 40 percent complete. About 70 percent of the underfloor piping and electrical conduit have been installed. Work on the basement walls was delayed two weeks while awaiting delivery of two sump tanks that were to be buried near the wall.

CAH-977 Facilities for Radioactive Inhalation Studies

No action is being taken on this project until the plan to relocate the Biology Laboratory has been resolved.

CAH-982 Addition to Radionuclide Facilities - 141-C Building

No action is being taken on this project until the plan to relocate the Biology Laboratory has been resolved.

CAH-100 High Temperature Lattice Test Reactor

Design is 75 percent complete compared to a scheduled 65 percent. Vitro has been authorized a total of $259,000 for design work. These funds have been expended, and design efforts have been curtailed awaiting authorization of additional money. All detailed design drawings and specifications for the Phase I construction package were reviewed by the Company. Our comments were submitted to the Commission. A Hanford Laboratories "HTLTR Gas and Materials Compatibility Review Committee" was formed to resolve materials problems on a more formal basis. Construction of the large mock-up in the 314 building was reactivated following a shift of research and development funds. A prototype safety rod (less poison section) has been fabricated and is undergoing tests. Fabrication of the control rod drive assembly is under way.

A directive modification dated June 19, 1964 authorized the Commission total project funds in the amount of $2,500,000.

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CAH-116 PRTR Decontamination and D_2O Cleanup

Detailed design is 72 percent complete compared to a scheduled 100 percent. Drawings are being reviewed and commented upon as they are received. Vitro was authorized an additional $3,000, bringing the total amount authorized for performance of Title I and II design services to $40,000.

CAH-119 PRTR Storage Basin and Experimental Facilities Modifications

Design is 86 percent complete compared to a scheduled 100 percent. Directive AEC-230, Modification 1, dated June 11, 1964, authorized total project funds in the amount of $510,000. The Company recently received and reviewed copies of heating, ventilating, and air conditioning flow diagrams. Vitro was authorized an additional $5,500, increasing the total funds authorized for performance of design services to $36,500.

CAH-123 Laboratory Fire Protection System

The Commission's project review board deferred action on this project at its June 11, 1964 meeting. The design criteria document was revised and approved.

CAH-126 Waste Transport System

The Commission wrote a revised project proposal requesting $31,000 for performance of design. The proposal was approved by the Commission's project review board on June 11, 1964. A directive dated June 22, 1964 authorized interim funds in the amount of $27,000 for performance of design. Vitro was authorized $22,000 on June 29, 1964 for performance of design.

CAH-128 Heat Transfer Apparatus for Model Studies - 189-D Building

The project proposal was returned unapproved.

CAH-136 Service Addition - 327 Building

A directive was issued on June 4, 1964 authorizing total project funds in the amount of $141,500. A work authority was issued on June 8, 1964 authorizing Vitro $20,000 for performance of design services.

CAH-137 Temporary Physical Sciences Center

The design criteria document was submitted to the Commission for approval on June 16, 1964. Components that will occupy the former Army Headquarters building (now designated the 3201 building), are determining maintenance requirements.

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CAH-146 Atmospheric Physics Building

The project proposal requesting authorization of design funds in the amount of $35,000 was approved by the Commission's project review board on June 11, 1964. It will be forwarded to Washington-AEC with a request for authorization.

CAH-151 Office Addition - 308 Building

The Commission authorized total project funds in the amount of $110,000 by a directive issued June 15, 1964.

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 Project CAH-916, FRPP and CAH-962, Low Level Radiochemistry Building; (2) engineering consultation on Vitro design of CAH-100, HTLTR and review of instrumentation drawings and procurement specifications; (3) preparation of design criteria for CAH-137, Temporary Physical Sciences Center; (4) liaison with IPD on HL requirements for reactor area services related to reactor plant deactivation; (5) review of Vitro design on CAH-106, PRTR Storage Basin Addition; and (6) preparation of design criteria for a dissolution cell in 325-B, an addition to 314 building, and an addition to 3718 building.

Facility planning and budget study work included: (1) layout studies for a plutonium fabrication facility addition to 308 building; and (2) study work on aerial photos of 300 Area for planning of long-range laboratory growth.

Engineering and consulting work was provided to research and development personnel as requested. Major work items included: (1) engineering assistance on J. A. Jones fabrication of the 105-KE experimental spectrometer; (2) engineering assistance to delineate scope of service piping for 324 building waste calcination; (3) consultation on instrumentation on several high pressure loops in the 314 building; (4) preparation of specifications for instrument and electrical components for 314 gas loop; (5) analysis of power source required for 1,000,000 ampere welder in 308 building; and (6) assistance on installation of 325 NMR electrical isolation system

Plant engineering work during the month included: (1) analysis and engineering of modifications to criticality alarm systems to improve reliability; (2) preparation of layout for fume hood in 305-B; (3) preparation of purchase specification for spare hoods for 325 and 329; (4) analysis of proposed 308 crib waste drain line; (5) analysis of problem of oil in 308 compressed air;

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(6) load testing and preparation of operating procedure for 325 emergency generator; and (7) engineering assistance on installation and check-out of retention waste monitors and flow meters.

Consulting service for other departments included instrumentation consultation to CPD on the 234-5 building dry air system controls and the Fab Oil Prototype Facility.

Pressure Systems

Assistance was provided to Chemical Effluents Technology for adapting an existing vessel for use in the 271-CR building. Code forms have been requested from the original vendor.

The Travelers Insurance Company third-party inspector inspected vessels in 209-E and 242-B buildings. Minor recommendations were made on vessel maintenance.

Analysis is being made of the 2000° F gas loop being installed in 314 building for ASME and ASA code conformance.

Analysis is being made and consultation provided on code equipment for the liquid sodium loop in 314 building.

Facilities Operation

Landlord costs for the month of May were $104,303, which is 78 percent of the forecast for the month. Fiscal costs for 11 months are $1,741,397, which represents 98 percent of the predicted.

Waste Disposal

The following table summarizes the Waste Disposal Operation:

Item	April	May
Concrete waste barrels disposed to 300-wye burial ground	2	0
Concrete waste barrels disposed to 200-W burial ground	5	12
Loadluggers of dry waste disposed to 300-wye burial ground from 300 Area sites other than the 325 building	20	20

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Item	April	May
Loadluggers of dry waste disposed to 300-wye burial ground from the 325 building	5	3
Loadluggers of dry waste disposed to 200-W burial ground from 300 Area sites	6	5
Containers of high level dry waste disposed to 300-wye burial ground vertical pipes	93	86
Crib Waste Volume, gal.	290 000	380 000

Two dry waste disposal tanks are being installed at the 300-wye burial ground. These tanks will be used to dispose of high level dry waste contained in metal containers in place of the vertical pipes now in use.

None of the retention basins exceeded the Class II activity levels.

Retention waste flow monitors for buildings 325, 326, 327, 329, and 308 have been installed in the lines. They will be put into service as soon as the electrical hookup is completed. Installation of the retention waste activity monitors is held up until component parts are tested.

The 340 building phone number 3420 has been put on the "Crash Alarm" system.

Building Operations

Wind and rain on June 15 caused moderate variations of 308 building statics. Static pressure remained negative but exceeded desired pressures during the storm. Modification of the sensing element to prevent wind disturbances is being studied. The reheat coils on #4 supply unit have corroded enough to require replacement. Control of filming amine addition is being investigated.

The diesel generator set at 325 building was tested on June 24 during swing shift. Operation of the unit was satisfactory for either No. 1 or No. 2 exhaust fans. Some reduction of timing sequence will be made to reduce the delay between the normal electrical failure and switching over of this unit to emergency operation.

The 333 building has been added to the filter drop checks taken each month.

1237431

Drafting

The equivalent of 205 drawings was produced during the month for an average of 22 man-hours per drawing.

Major jobs in progress are: (1) ultrasonic tester for irradiated fuel elements, N Reactor; (2) high temperature furnace, 306; (3) powder processing line, 231-Z; (4) 309 building piping service drawings; (5) FRPP service piping to waste calcination equipment; (6) critical mass physics safety and control rods; (7) bellows expansion tank for critical mass study; (8) high vacuum plutonium research glove boxes; and (9) underwater measuring equipment, N Reactor.

Drafting service was also supplied in support of engineering and budget study work as previously reported.

Construction

Major nonproject jobs in progress during the month were: (1) construct swine farrowing barn and pens, 141-F; (2) modify heating and ventilating system, and install intercom, 144-F; (3) install third-floor partitions, 108-F; (4) construct new dog runs and modify existing dog runs, 144-F; (5) modify dark room, 1706-KEL; (6) install fire detection, 100-F Area; (7) construct pasture and sprinkler system at meteorological tower; (8) modify and install hood 44, 308; (9) construct autoclave pit, storage area, EDEL-II loop foundations, and HTLTR mock-up, 314; (10) construct thoria laboratory room 417, and install emergency generator, 325; (11) construct manhole and retention waste bypass line and install snubbers in high pressure lines, 309; (12) install electrical services and air conditioning for computer, 321; (13) install hydrogen system, install air conditioning unit in metallography lab, and install rectifier for arc melt furnace, 306; (14) construct offices and storage addition, 328; and (15) construct personnel change and survey building, 340.

Containment Systems Experiment - Design and construction work progress continues as scheduled. Chicago Bridge and Iron Company progress on the containment vessel is satisfactory. Contract award for fabrication of the simulator vessel has not been made. Investigative work by J. A. Jones Company prior to negotiation of a contract is proceeding.

Renovation of Wells - The subcontractor has completed the ten wells per the contract.

1237432

Waste Solidification Prototype - Fabrication work is on schedule.

Crane Safety Inspection - The inspector reported on site June 23 and is expected to complete all work by July 10, including work for CPD and IPD. Plans are being formulated for continuing crane and hoist surveillance, and a new contract will be negotiated for inspection services.

GENERAL

There were no reports of inventions or discovery during the month.

W. Sale
Manager
Finance and Administration

W Sale:RDT:whm

REACTOR DEVELOPMENT - 04 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Plutonium Recycle Test Reactor

Operation

Reactor output for June was 903 MWD for an experimental time efficiency of 59% and a plant efficiency of 44%. There were six operating periods during the month, three of which were terminated by scrams and three were terminated manually. A summary of the fuel irradiation program as of June 30, 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		7	1586.0	78	11723.6			85	13309.6
Maximum				303.8		302.6				
Average				226.6		150.3				
In Basin	7	572.5	25	2673.1	40	3768.3			72	7013.9
Buried							1	7.3	1	7.3
Chem. Process.	68	5465.8	35	1965.8					103	7431.6
Program Totals	75	6038.3	67	6224.9	118	15491.9	1	7.3	261	27762.4

Note: (MWD/Element) X 20 $\simeq$ MWD/TU for UO_2 and PuO_2-UO_2.

Indicated helium loss for June was 134,876 scf. Heavy water loss for June per physical inventory was 73 pounds (adjusted).

On June 22, 1964, 20,611 pounds of scrap heavy water were shipped to Savannah River.

Equipment Experience

A total of 138 reactor outage hours was charged to repair work. Main items were:

Shim rod replacement
Rupture Loop repairs
"B" dump valve repair
D_2O leak repairs
Pressurizer float switch repair
Moat rupture disc replacement

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Preventive maintenance required 412 hours, or 7% of the total maintenance effort (assigned craftsmen).

Improvement Work Status (significant items)

Work Completed

Control Room Backup Station
Repair of Inspection Pump Discharge Line
Anchoring of Spray Nozzles and Strainer Replacement
In-line Gas Sampling

Work Partially Completed

Corrosion Loop Installation
Primary Water Sample Station
Process Tubes Level Indicator
Installation of New Alarm Annunciator
Vibration Snubbers for Earthquake Protection
Thermal Barrier Support Modification
Supplemental Emergency Water Addition

Design Work Completed

Voltage Off Normal Detection and Alarm for 24 Volt Battery System
Permanent Mounting of Aural Monitor
Arc Suppression on Safety Circuit Relay
PRTR Steam Utilization

Design Work Partially Completed

Flux Wire Scanning System
Gamma Scanner Cask Modifications
Thermal Barrier Seal & Hoist Improvements
Pneumatic Irradiation Facility
PRTR Experimental and Building Facilities Addition
PRTR Increased Power Level
Creep Test Facility
Installation of Secondary Generation Shim Rod

Process Engineering and Reactor Physics

PRTR Test 63, Reactivity Worth of Coolant Removal from Fuel Channels, was performed during June. The results are summarized in the following table:

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Fuel Type (unirradiated)	Location (Ring)	Reactivity Change on Voiding (milli-k/channel)
UO_2	1	+ 0.048 ± 0.010
UO_2-1 w/o PuO_2	5	- 0.007 ± 0.008
UO_2-0.48 w/o PuO_2	9	- 0.041 ± 0.015

A fuel substitution measurement was performed as part of Test 63. The reactivity worth of unirradiated UO_2-0.48 w/o PuO_2 and UO_2-1 w/o PuO_2 fuel elements were compared in Ring 5. At that location, the 1 w/o elements were worth about + 1.08 milli-k/element more than the 0.48 w/o elements.

The measurements performed in Test 63 resulted in a good estimate of the accuracy and reproducibility of approach-to-critical measurements in PRTR. It was determined that comparative measurements can be made with an accuracy of ± 0.02 milli-k on each measurement, a precision adequate for many experiments.

PRTR Test 73, Supplement 2, Maximum River Pump - Filter Plant Flow Capacity, was re-run with satisfactory results. The analysis of the results will be included in the Test Report.

The reactor was started up, following the extended outage, with approximately 0.1% hydrogen in the helium supply as authorized by PRTR Test 93. This low concentration was not noticeably effective in controlling oxygen in the systems, which had become air contaminated during the outage. Since startup, concentrations up to 0.6% hydrogen in supply helium have been used, with favorable reductions in oxygen in the reactor systems. However, there are continued evidences of buildup of deuterium and oxygen which do not tend to recombine without an excess of hydrogen present.

The use of monosodium phosphate addition for HX-1 pH-phosphate control was initiated on a routine basis following the extended outage. Equilibrium pH-phosphate control has been adequate, requiring approximately 300 ppm phosphate in the boiler to maintain a pH of approximately 11.3.

During the extended outage, a borescope inspection of a shim rod access hole was performed. This inspection revealed rusting and spalling near the bottom of the top shield shim rod access hole. Corrective action has been initiated.

1237436

In support of reactor safeguards analyses, calculations of the fission product inventory associated with a 120 MW reactor was performed using the RIBD computer code. The dose rates from the containment vessel resulting from a maximum credible accident were calculated by a machine code written especially for that calculation using fission product gamma energy data from a compilation in a Canadian document, CRDC 1007.

Formulas and charts for the calculation of critical fission products for fuel reprocessing were derived. It was found that the limiting isotopes for NFS processing are Zr Nb-95 and I-131.

Experimental Reactor Services

The status of the various test elements at the end of June 1964, is shown below. Those elements which had reached their assigned goal exposure or had been permanently discharged for other reasons prior to June 1, 1964, have been deleted from the table.

Test No.	Channel Location	Number	Description	Date Initial Charge	Discharged	Approximate Accumulated MWD
14	1956	5097	Moxtyl-Swaged	4/2/62	--	189.8 repad
14	1352	5098	Moxtyl-Vipac	5/8/62	--	285.2 repad
14	1758	5099	Moxtyl-Vipac	5/8/62	--	203.0 repad
48	1156	5150	Moxtyl ($\frac{1}{2}$" x $\frac{1}{2}$" pads)	8/1/62	--	198.7
54	1542	5116	Moxtyl (clip-on pads)	5/8/62	--	207.7
54	1554	5118	Moxtyl (clip-on pads)	5/8/62	--	302.6
61	1249	5185	Moxtyl-Physics	5/28/63	--	194.8
61	1354	5186	Moxtyl-Physics	5/28/63	--	187.8
61	1445	5192	Moxtyl-Physics	6/13/63	--	195.2
67	1946	5119	Moxtyl (Repaired wire)	10/20/63	--	117.2
67	1047	5117	Moxtyl (Repaired wire)	10/20/63	--	159.0
80	1544	5214	Moxtyl (1% PuO_2, Swaged)	11/18/63	--	135.1
85	1855	5230	Moxtyl (1% PuO_2, Vipac)	1/30/64	--	81.2
37	1548	1098	UO_2-Physics	5/12/62	--	181.9
37	1550	1097	UO_2-Physics	5/12/62	--	194.6
37	basin	1100	UO_2-Physics	5/12/62	--	151.3
37	1552	1099	UO_2-Physics	5/12/62	--	164.0

Twelve old ruptured fuel elements were inspected for possible splits in the cladding. No splits were observed, although element 5203 was periodically emitting gas bubbles. Three rods were removed from each of the elements 1096, 1100 and 5213. They are scheduled for shipment to Radiometallurgy in July. Process tube 5526 was cut up and sections were shipped to Radiometallurgy for examination.

1237437

Plutonium Recycle Critical Facility

Measurements of fuel worth, void worth and the worth of selected absorbing materials at various core positions were completed. Irradiations for measurement of the neutron spectrum and for flux distributions in the core were performed. Preliminary temperature coefficient of reactivity data was obtained.

Fuel Element Rupture Test Facility

The Rupture Loop was removed from service on June 14, 1964, when it was found that the mixed bed ion exchange unit had failed and introduced loose resin into the main piping. The loose resin has been flushed out, ion exchangers have been refilled, and the jumpers fabricated. At month-end, the Rupture Loop was ready for pre-operational testing.

The UO_2 water tube test element (FERTF Test No. 9) achieved a power of 356 kw, corresponding to a reactor power of 40 MW, and accumulated an exposure of about 0.85 MWH before the reactor was shut down.

Chemical Processing of Spent PRTR Fuels

Further chemical analyses of the PuO_2, which was received during the April Redox Campaign, has shown $\sim$2 ppm boron contamination. The material has been accepted for fabrication.

TECHNICAL SHOPS OPERATION

Total estimated productive time for the period was 25,352 hours. This includes an estimated 15,209 hours performed in Technical Shops, 7,645 hours assigned to J. A. Jones Company, and 2,498 hours assigned to offsite vendors. Total shop backlog is estimated to be 16,250 hours, of which 90 percent is required in the current month with the remaining hours distributed over a three-month period. Overtime worked during the month totaled 922 hours, or 5.0% of the total available hours.

Estimated distribution of time was as follows:	Man Hours	% of Total
N Reactor Department	2,307	9.1
Irradiation Processing Department	4,411	17.9
Chemical Processing Department	634	2.5
Hanford Laboratories	17,998	71.0
Hanford Utilities & Purchasing	2	nil

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LABORATORY MAINTENANCE OPERATION

Total productive time was 18,700 hours of 21,200 potentially available. Of the total productive time, 92% was expended in support of Hanford Laboratories components, with the remaining 8% directed toward providing service for other HAPO organizations. Craft overtime worked during June was 4.9% of total available hours.

Manpower utilization (in hours) for June was as follows:

A.	Shop Work		2 100
B.	Maintenance		7 100
	1. Preventive Maintenance	2 000	
	2. Emergency or Unscheduled Maintenance	1 700	
	3. Normal Scheduled Maintenance	3 400	
C.	R & D Assistance		9 500

Responsibility for supplying craft support to the Hanford Laboratories portion of the 306 Building was assumed by the Laboratory Maintenance Operation June 1, 1964.

WD Richmond

1237439

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
G. B. Barton	Preparation of Intimate Mixtures of Tungsten Metal and Uranium Dioxide
G. B. Barton	Generation of Droplets by a Vibrating Element
R. W. Stromatt, J. R. Lundquist, R. L. Braun and G. F. Jacky	Use of Bromide in Solutions for Nickel Plating Uranium
R. E. Sharp and W. J. Bailey	Long-Life, High-Heat-Flux, "Water-Tube" Type Nuclear Fuel Element with Replaceable Fuel Inserts

Manager, Hanford Laboratories

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