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HANFORD LABORATORIES OPERATION
MONTHLY ACTIVITIES REPORT

JANUARY, 1961

FEBRUARY 15, 1961

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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JANUARY, 1961

Compiled by
Operation Managers

February 15, 1961

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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TABLE I. HLO FORCE REPORT AND PERSONNEL STATUS CHANGES

DATE January 31, 1961

	At close of month			Beginning of month			Additions		Separations	
	Exempt	NonExempt	Total	Exempt	NonExempt	Total	Exempt	NonExempt	Exempt	NonExempt
Chemical Research & Development	127	120	247	126	124	250	2	3	1	7
Reactor & Fuels Research & Development	200	185	385	201	185	386	1	2	2	2
Physics & Instr. Research & Development	84	40	124	82	38	120	2	3	0	1
Biology	34	48	82	34	49	83	0	0	0	1
Operation Res. & Syn.	16	4	20	16	5	21	0	0	0	1
Radiation Protection	39	98	137	38	97	135	1	3	0	2
Laboratory Auxiliaries	53	199	252	52	201	253	1	6	0	8
Financial	14	16	30	14	16	30	0	1	0	1
Prof. Placmt. & R. P.	72	11	83	76	11	87	3	0	7	0
Programming	13	4	17	14	3	17	0	1	1	0
General	2	3	5	1	3	4	1	0	0	0
Totals	654	728	1382	654	732	1386	11	19	11	23
Totals excluding internal transfers	654	728	1382	654	732	1386	9	11	9	15

BUDGETS AND COSTS

January operating costs totaled $2,122,000; fiscal year-to-date costs are $14,680,000, or 57% of the $25,911,000 control budget.

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

(Dollars in Thousands)	Cost				
	Current Month	Last Month	FY To Date	Budget	% Spent
HLO Programs					
02 Program	$ 32	$ 37	$ 293	$ 661	44
04 Program	822	810	5 447	9 494	57
05 Program	76	68	460	796	58
06 Program	169	177	1 338	2 372	56
	1 099	1 092	7 538	13 323	57
IPD Sponsored	271	262	1 871	3 170	59
CPD Sponsored (Excluding Strontium-90 Program)	145	159	1 119	1 693	66
Total	$1 515	$1 513	$10 528	$18 186	58%

RESEARCH AND DEVELOPMENT

1. Reactor and Fuels

Construction completion of PRTR and associated facilities is as follows: PRTR Phase III-A, 92% complete; Maintenance and Mockup Facility, which includes the Rupture Loop Annex and the Critical Facility Building, 33%; and Gas Loop, 55%. Designs of the Critical Facility and Rupture Loop are complete. Beneficial use of the PRTR stack filter was obtained during the month.

PRTR Critical Tests continued with further determinations of moderator level coefficients, shim system strength and coolant void effects, and with sub-critical measurements using all-plutonium fuel loadings. A maximum total shim system strength of about 130 milli-k, and a maximum single-rod strength of about four milli-k were found. These values are about 30 percent higher than previous estimates based on single rod measurements. Extrapolated results of sub-critical measurements indicate criticality with 12 Pu-Al fuel elements loaded in the central tubes at a moderator level of 101 inches and with 36 Pu-Al elements at a moderator level greater than 30 inches.

Experiments on arc-melted PuC-UC systems indicate that increased additions of UC tend to suppress the quantity of Pu_2C_3 formed upon passing the PuC peritectic temperature of 1650 C. Complete stabilization of the

face-centered cubic PuC-UC structure occurs with slightly greater than 25 weight percent UC.

"Salt cycle" UO_2 remotely fabricated into a fuel element was successfully irradiated in the Materials Testing Reactor to an exposure of 700 MWD/T at a maximum surface heat flux of 600,000 BTU/hr-ft^2.

Ex-reactor thermal conductivites of irradiated UO_2 are markedly lower than for unirradiated materials at low temperatures. Annealing begins at about 175 C but lower thermal conductivity, by about 10-15%, still remains at 600 C.

The first KER loading of enriched single tube elements was discharged after attaining an exposure of 1200 MWD/T. Basin examination showed no obvious changes in the elements as a result of irradiation. No apparent dimensional instability or swelling in the heat-affected zone of the braze closure area was detected.

The hydriding of Zircaloy-2 and Zircaloy-4 by corrosion-product hydrogen in refreshed and static autoclaves is governed by the concentration of oxygen in the system.

Creep studies of annealed Zr-2 and 20% cold worked Zr-2 in the temperature range of 200 C to 270 C show that the activation energy for creep is negligible in this temperature range.

With technical assistance from Hanford, one fabricator has successfully produced and delivered nine Zircaloy-2 tubes for the overbore test at C Reactor within nine weeks of the date of signing the contract.

The fifth intentional fuel rupture test in the Engineering Test Reactor operated at full power for 2-1/2 hours after the defect cap was sheared off. The swelling of the tubular NPR specimens nearly blocked the water annulus, making removal from the basket difficult.

It is believed that non-uniform clad thickness on NPR fuel is the primary contributing factor in the mechanism which caused failure by clad splitting of several NPR fuel elements.

Excellent dimensional stability was shown by a U-Mg fuel element irradiated to 15,000 MWD/T in the ETR. Microscopic examination of the U-Mg core material revealed that the original spherical uranium particles have been greatly distorted and the magnesium matrix material has accommodated this distortion by plastic yielding.

The effect on heat transfer conditions of the non-coaxial placement of I&E fuel elements within a process tube was demonstrated in the laboratory.

When an electrically heated element was displaced 50% and 75% of the distance upwards toward the wall of the process tube, the water temperatures at the top of the annulus increased significantly and boiling burnout took place at a reduced heat flux.

A zirconium process tube and fittings procured for the overbore program at C Reactor were installed in the 189-D hydraulics laboratory to verify the hydraulic design of the tube and self-supported I&E fuel elements. The pressure drop as measured across the fuel elements was 12% less than the design value of 270 psi but can be compensated for by increasing the pressure drop across other components in the tube.

Purified fused silica is the most radiation resistant optical grade glass or plastic of several considered for use on in-reactor optical equipment. It is virtually unaffected by a gamma dose of 5×10^9 roentgens.

2. Chemical Research and Development

A mixture of aluminum sulfate and calcium chloride formed an effective and cheap scavenging precipitate for treating NPR decontamination solution. This method appears superior to using ferrous sulfate and potassium permanganate.

Thirteen and one-half kilocuries of strontium-90 were recovered in pure form from two ion exchange runs made during the month. Isotopic purity of the product was 56% strontium-90, very close to the theoretical ratio of Sr-90 to total strontium. Other than Sr-90 and its yttrium daughter, no other radioactivie impurity was detectable in the product material. Refractory solids in the strontium concentrate feed, a lower than expected resin capacity, and radiolytic reduction of copper in the resin system all were problems encountered in these experiments. Work to minimize these complications in future recoveries is underway. Initial decontamination of cell equipment was started to allow repair of some leaks before subsequent recoveries are undertaken.

Conversion of the Hot Semiworks for strontium-90 recovery is about 85% complete. Flowsheet developments continue to be encouraging and preparations for miniature mixer settler runs using actual Purex strontium-90 concentrate were virtually completed. Radiolysis studies of synthetic feed solutions showed the system was stable for time periods expected during processing. Radiolytic effects in actual processing will require careful surveillance, however. Final strontium product preparation and shipping problems are under study.

Continuing experiments to define the mechanisms by which plutonium and uranium oxides co-deposit in the Salt Cycle Process showed air and/or water vapor play a role in the process. These results coupled with electrode

polarization studies provided several hypotheses regarding reactor mechanisms but conclusive results await more testing data.

Study of KCl-$PbCl_2$ salt mixtures as an alternate to KCl-NaCl for Salt Cycle media showed uranium dioxide dissolution and electrodeposition characteristics which are quite favorable by comparison and, of course, occur at a much lower temperature (450 C vice 700 C). It is clear that electrodeposition characteristics in the KCl-$PbCl_2$ system are distinctly different from those in KCl-NaCl. These favorable results must be tempered by planned studies of plutonium behavior in the KCl-$PbCl_2$ system.

The Radiant Heat Spray Calciner has been reassembled with an improved filter unit. Two runs indicated satisfactory filter performance. The new filter design shortens the unit to allow ultimate in-cell testing in the High Level Radiochemistry Facility.

A bed of Florida pebble phosphate was found to be effective for removing plutonium from 234-5 sump waste, adsorbing more than 90% from over 400 bed volumes processed. Adsorbed plutonium is easily removed with a carbonate wash.

3. Physics and Instrument Research and Development

Continual progress in NPR support work was highlighted by measurements of the fuel temperature reactivity coefficient at temperatures fifty percent above those previously attained anywhere in such experiments with uranium metal fuels. Data were obtained at temperatures up to 968° C. In other work, strengths of several control rod configurations were determined in exponential experiments, the first use of this technique locally. Calculations of neutron behavior in the lattice cell using the RBU code made progress as did instrumentation support work in the areas of fuel failure and radiological monitoring. Transient behavior of the NPR system continued under study following its successful simulation reported last month and data for use in design of automatic control systems were obtained from observations on an existing reactor.

At the Critical Mass Laboratory testing of safety and control mechanisms and instruments proceeded satisfactorily and minor modifications to the building were completed. Procedures to be followed in event of an emergency are under discussion with CPD before being formalized. Meanwhile the correlation of existing data on plutonium solutions with calculation methods made progress with resolution of previous difficulties in treating reflected systems. The method was then applied in obtaining nuclear safety limits supplied to CPD for use in the calcination of plutonium nitrate solution.

The shim rod system of the PRTR is as strong as originally expected according to results of recent tests which dispelled some concern on this

score created by earlier incomplete results. Analysis of other critical experiments indicated that the effect of the reflector was less than indicated by the calculation methods used.

In other PRP work, design improvements were incorporated in the Gas Annulus Measurement probe and development continued on the process tube wall thickness probe. Technical planning for studies with high exposure plutonium continued in an effort to achieve technical sophistication while remaining within the limits of what is achievable experimentally.

In the Nondestructive Testing Program, continued encouraging results were obtained in the development of direct thermal methods to bond testing with the laboratory application of the method to a number of Hanford, AlSi process, fuel elements.

Orderly progress was made on the many instrument development studies including completion of new data handling equipment at the whole body counter, improved techniques for using thermoluminescent dosimeters, and completion of a calibration system for in-reactor creep measurements.

4. Biology

About half of the waterfowl sampled from local hunters contained detectable amounts of P^{32}, indicating that this may be a more significant source of exposure to people in the Tri-City area than estimated in the past.

The virulence of columnaris organisms isolated from local fish varied with the month of collection. The least virulent strain was obtained in July (water temperature 66 F), the most virulent was obtained in October (68 F), and the strain obtained in November (61 F) was intermediate.

Radiation dose measurements of Cs^{137} in sheep indicate that the gonads and the whole body are of about equal importance as the "critical organ". The turnover rate for cesium in the heart muscle was found to be very fast -- exceeding 200 percent per day compared with 10 percent per day in voluntary muscle.

Whole-body counting looks promising as a means of determining the body burden of Sr-90 in vivo. Preliminary results with this method on swine indicate that after prolonged feeding, the body burden is about 10 to 15 times the dose fed daily.

Work with swine showed that if a small skin wound is contaminated with plutonium, over 80% will be removed by the scab which forms.

In studies with $Pu^{239}O_2$ particles, there was an indication that particle size and total quantity of Pu deposited affected lung retention and urinary excretion.

Such factors are important to inhalation hazard evaluation and to bioassay interpretations.

5. Programming

Recently-completed parameterized computer calculations of fuel costs for stainless steel clad vs. zircaloy clad fuel assemblies are expected to be valuable to fuel development personnel in guiding the design of more economical fuel elements for various reactor uses.

The design study of the Beloyarsk Russian Superheat reactor has provided a convenient check case for the Specific Fuel Cycle Analysis computer codes. For batch irradiation of the fuel, the calculated minimum value of plutonium is approximately $14/gram, which is close to the mean value calculated for the Advanced Pressurized Water Reactor (APWR).

An integrated plutonium value analysis computer code is nearing completion. The code combines physics, economics, reactor operating, and fuel cost parameters to calculate the value of plutonium as a power reactor fuel for a selected range of reactor systems, and is intended to help guide reactor design and fuel development activities toward optimum utilization of plutonium-bearing fuel.

TECHNICAL AND OTHER SERVICES

There are 17 currently active projects having combined authorized funds in the amount of $19,047,000. The total estimated cost of these projects is $20,922,000. Total expenditures, on these projects, through December were $14,757,000. In addition, project proposals have been submitted to the Commission requesting authorization of $670,000 on six new projects for which the total combined costs are expected to approach $5,620,000. Of the 17 authorized projects all but two are on or ahead of schedule.

Project CGH-819 - Increased Laboratory Waste Facilities, was completed during the month with only minor exceptions remaining. Authorized funds were $193,765, with a scheduled completion date of May 31, 1961, compared to actual costs of $165,000 and completion January 31, 1961. Both the cost and schedule reflect less contamination problems during construction than were estimated as well as the excellence of the working relationships of J. A. Jones Company and the subcontractors.

The 1960 annual inventory of Secret Research and Development reports and of Weapon Data reports was started January 3 and completed January 24 in record breaking time. Results of the inventory are as follows: 10,196 accountable copies of which 1,049 are Weapon Data reports and 9,147 are R & D reports; 29 copies unaccounted for from previous years, none unaccounted for this year.

The periodical automation program is essentially completed and the system "debugged". Sample lists and reports have been printed from the tape and subscription renewals are being handled with cards printed from taped information.

Declassification review of the early 3-series of Hanford documents has been completed. The classification on approximately 480 of the documents has been retained. The remainder of the nearly 5,000 documents has either been declassified or, in the case of those having no future reference value, destroyed.

Additional analyses were performed on post-irradiation data for production tests involving bumper fuel elements. These analyses provided new insights into the effectiveness of the prevention of hot spot failure and the nature of corrosion mechanisms.

Coding of the computer program for the Z-Plant study has been completed. The computer was delivered late in January and machine debugging will be started in the near future.

Four cases of plutonium contaminated injuries to fingers, two requiring excision of skin, occurred to Chemical Processing Department operators. One additional case of minor plutonium deposition was confirmed during the month, bringing the total to 269 of which 264 have occurred at HAPO. There are currently 192 cases on the active rolls.

A review of internal deposition experience for 1960 showed there were 28 employees who received measurable deposition of plutonium, 9 employees received mixed fission product deposition and one employee received uranium deposition. The maximum case was equal to or less than 10% of the maximum permissible body burden. Inhalation and minor injuries to the hand continued to be the principal modes of internal exposure.

Four Radiation Protection Operation exempt employees, as members of the Radiological Assistance Team, were requested by the Idaho Operations Office to assist in operations as the site of the SL-1 reactor accident at the National Reactor Test Site, Arco, Idaho.

SUPPORTING FUNCTIONS

Hanford Laboratories received an additional $35,000 allocation for Miscellaneous Capital Work Orders under $20,000. This allocation brings FY 1961 funds up to $150,000. At month end, $107,200 had been expended and $17,200 was committed leaving an unencumbered balance of $25,600.

There are currently 563 items valued at $222,000 located in the equipment pool. Twenty-eight items valued at $12,000 were placed in use status during the month in lieu of placement of purchase requisitions.

As of January 31, 1961, the staff of the Hanford Laboratories totalled 1382 employees, including 654 exempt and 728 weekly salaried. Of the total, 562 possess technical degrees, including 333 B.S., 124 M.S. and 105 Ph.D.

The medical treatment frequency for January was 1.41 as compared with 1.32 for the preceding month. There were no disabling injuries or serious accidents during the month. There was 1 security violation during the month, as compared with 2 for the corresponding period last year.

To date, 43 offers were extended BS/MS candidates for the Technical Graduate Program. Of these, 7 acceptances and 7 rejections have been received.

Ph.D. employment activity included 8 interviews, with 2 offers extended (Chemists-HL), one acceptance (Chemist-HL) and 4 rejections (Chemists-HL).

To date, 7 professors have accepted HAPO offers to participate in the Summer Employment Program.

A supplemental recruiting brochure, "Living in the Tri-City Area," was completed and is now in use.

Open requisitions at the beginning of the month totalled 23. There were 10 new requisitions received, 14 vacancies filled, and 2 cancelled.

Listed below is a summary of training activities.

Course or Seminar	Number of People	Status
PBM-I	41	Continuing
Creative Approach	10	Continuing
Technical Report Writing	7	Continuing

Dr. I. H. Dearnley joined the staff of the Hanford Laboratories as University Representative. Dr. Dearnley will be concerned with identifying areas of common interest between academic institutions and the Laboratories and in promoting their appropriate development.

for L. P. Bupp
Manager
Hanford Laboratories

HM Parker:mlk

1234029

REACTOR AND FUELS RESEARCH AND DEVELOPMENT OPERATION

TECHNICAL ACTIVITIES

A. FISSIONABLE MATERIALS - 2000 PROGRAM

1. METALLURGY PROGRAM

Corrosion Studies

Effect of Hydrogen Pressure on Hydriding of Zircaloy-2. When Zircaloy-2 is exposed to mixtures of water vapor and hydrogen, the water vapor severely inhibits the hydriding reaction as long as enough water is present to maintain the normal oxidation rate. Previous data on 30-mil thick samples indicated that increasing the hydrogen pressure from 1 to 400 mm had no effect on the hydriding reaction as long as excess water was available. This experiment was repeated on 5-mil foils of the same area, which increased the sensitivity of the experiment by a factor of six. The water pressures were chosen to be just sufficient to supply the required water to maintain the oxidation rate. The unstable nature of the system at p_{H_2O} = 0.5 mm is indicated by two similar experiments, one of which produced no hydriding, the other catastrophic hydriding. Longer term data at p_{H_2O} = 400 mm show no hydrogen pickup due to the 400 mm hydrogen partial pressure. These results confirm the earlier observations.

In a similar experiment on 30-mil vapor-blasted samples, a small effect of the hydrogen pressure is indicated by the higher than normal calculated percent of theoretical hydrogen pickup values. More experiments are planned to confirm this observation.

Hydriding of Zircaloy-2 in Glow Discharge. There has been interest in what effect atomic hydrogen would have on the hydriding of Zircaloy-2. A Zircaloy-2 foil was heated to 400 C in high vacuum and H_2 at one mm pressure and H_2O at 0.1 mm pressure were added. An electric glow discharge was set up by impressing a 1500 volt AC power supply across electrodes into the furnace tube. The Zircaloy-2 sample was one electrode. After 18 hours of exposure the sample was removed. The hydrogen pickup was 25 ppm, which compares with zero pickup in a similar experiment at p_{H_2} = 400 mm and p_{H_2O} = 1 mm. This result shows that either the electric field itself, or the atomic hydrogen that was generated by the discharge had an effect on hydrogen pickup. Further experiments are planned in which the zirconium samples are not part of the electrical circuit.

Corrosion of NPR Moderator Cooling Tube. In the event the cooling water is lost, the temperature of NPR moderator tubes would quickly rise to a high temperature and then slowly cool in a steam atmosphere. This sequence was approximated in a laboratory furnace. A piece of NPR moderator tubing was heated in a vacuum to 875 C. Pure water vapor at 23 mm pressure was then added, and the sample slowly cooled by a calculated rate over an hour and a half period. The sample had a black oxide film, a weight gain of

100 mg/dm^2, a hydrogen pickup of 180 ppm and a percent theoretical pickup of 35%. An appreciable quantity of oxygen probably was uniformly dissolved in the metal. This simplified experiment indicates that the loss of water to the tubes for a period of about one hour would result in some damage to the tubes but not catastrophic failure.

Etching and Autoclaving of Beryllium Brazed Fuel Elements. Considerable trouble has been experienced in the pilot plant in etching and autoclaving of coextruded uranium-core Zircaloy-2 clad fuel elements with beryllium brazed end closures. The welded ends of the fuel elements show grey-to-white areas after autoclaving rather than the normal black film. These grey-to-white areas appear to be caused by the beryllium present in the welds. A test program has been initiated to determine a suitable etching technique for beryllium-containing Zircaloy-2. To date, six 5-inch fuel elements and several 5% beryllium-Zircaloy-2 braze rings have been etched and autoclaved using standard Zircaloy etching procedures and sulfuric acid rinses. The material processed through the standard Zircaloy etch bath showed acceptable black films whereas the material processed through various concentrations of sulfuric acid rinses following the standard HNO_3-HF etch showed heavy white oxide on the weld zones.

Radiometallurgy Laboratory Studies

Metallographic examination of IP-292-A (enriched KER tube-in-tube elements) revealed that distortion and severe cracking due to uranium growth had occurred in the unalloyed uranium. The uranium-2% Zr alloy was in excellent condition after the 3100 MWD/T exposure (RM-569).

The ruptured tubular element from the fifth ETR defect test was badly swollen and had distorted the Zircaloy-2 basket. Approximately one-half of the uranium core had oxidized over a five-inch section in the defect area. Cladding was badly cracked and on the side of the defect part of the cladding had fallen away. The swelling had also collapsed the internal coolant channel (RM-574).

Examination of GEH-3-8, uranium-magnesium fuel element, showed that the spherical uranium pellets had become misshapen and many contained cracks after a 15,000 MWD/T exposure. In a few locations a metallurgical bond had formed between the cladding and the fuel core (RM-575).

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

Basic Metallurgy Studies

Radiation Effects in Structural Materials. In order to augment limited data on changes in mechanical properties of structural materials resulting from radiation damage, tensile specimens of Zircaloy-2, Zircaloy-3, aluminum alloys X-8001 and M-257, magnesium alloys HK-31A-H24, A-3XA-0, and AM-350 stainless steel were irradiated in the 105-KE magazine facility. Three charges accumulate exposures of 6.95 x 10^{19} nvt, 7.0 x 10^{20} nvt, and 1.2 x 10^{21} nvt thermal flux, respectively. As a continuance of the program,

the magnesium alloy tensile specimens have been tested. Data indicate that radiation tc the levels of this test does not significantly alter the mechanical properties of the HK-31A-H24 (3% thorium) alloy. This is not surprising since the H24 alloy was fully cold worked prior to irradiation. The A-3XA-0 (3% Al) alloy, however, follows the general pattern of radiation damage with yield strengths increasing from 13,700 psi to 28,400 psi and ultimate strengths increasing from 26,700 psi to 36,600 psi. The elongation reduced from 13% to 10%.

Electron and Optical Microscopy. The study of the microstructure of cladding and fuel material before and after irradiation is a direct way of detecting radiation induced damage in these materials. Studies of fission fragment damage in evaporated metallic films have continued. Multilayered films of the type carbon-X-UO_2, where X is Cr, Ni, Pd, and Be, have been irradiated. These films all contained discrete regions free of UO_2, and in these regions recoil fission fragment damage was observed. This damage is similar in all respects to that detected in previously reported films (Al, Ge, Pt, SiO_2, ZrO_2, WO_3). Experiments are now in progress to establish the influence of film thickness on fission track registration. Films of a given material are being evaporated in a manner that produces films with thicknesses which vary by a factor of two. The number of recoil tracks observed by transmission as a function of track lengths for various film thicknesses will be analyzed statistically. Similar analysis of the number of tracks of given lengths which decorate the free surfaces of the films obtained by shadowing the free surfaces of the film should help answer the following questions: How does fission fragment damage as revealed by electron microscope techniques vary as the distance between fragment path and the free surface increases? Can the direction of travel of the individual fission fragments be determined from a comparison of the top and bottom surfaces of the films?

A film prepared by electron beam evaporation of a 10 w/o U-Pd alloy onto a carbon substrate has been irradiated to 4×10^{16} nvt. Due to the extreme dilution of U-235, only a few tracks were observed. This type of specimen does not appear to offer advantages over layered, evaporated films, but may offer advantages if prepared as foils.

Thin foil preparation techniques involving use of a microtome equipped with a diamond knife are being developed. This technique may be of considerable help in preparing foils of chemically reactive metals.

Two articles, "Fission Fragment Damage in Non-fissionable Thin Films," and "Damage in UO_2 Films and Particles During Reactor Irradiation," were published in Journal of Applied Physics, December 1960.

X-Ray Diffraction Studies. Orientation of extruded uranium tubes and rods with various fabrication and heat treatment histories is being determined by several x-ray methods. Five HKL pole figures of alpha-extruded rod which had been cold swaged to 12.5 and 25% reduction in area have been obtained using spherical specimens 1/2" and 1/4" in diameter. While the alpha-extruded stock shows a strong a-axis component of texture at

approximately 20° to the extrusion axis, the cold swaged stock does not show this. The effect of swaging is to increase the relative amount of 010 component parallel to the deformation axis and to decrease the 110 axis component in the same direction.

During the current studies on x-ray line broadening of cold worked and irradiated molybdenum, it became apparent that the line broadening functions found experimentally were inconsistent with theory. The measurements were repeated using highly precise step scanning techniques. The improved data did not remove the difficulty but served instead to confirm the discrepancy. A re-examination of the experimental method revealed that the relative heights of the alpha-1 and alpha-2 peaks changed with degree of broadening. The Fourier method of determining broadening functions requires that this peak height ratio remain constant. It is necessary then to resolve the alpha-1 and alpha-2 peaks rather than to use the unresolved peak. A technique for doing this separation directly from the Fourier coefficients has been developed.

Molybdenum single crystals are being examined to determine their degree of perfection and their suitability for further study. The first crystals appear to have a mosaic spread of about 15 minutes of angle, roughly twice that usually associated with good single crystals. Intensity measurements for evaluating amount and type of extinction have been made, but a correction for crystal shape must be applied before any conclusions can be drawn.

The experimental work on the annealing of molybdenum irradiated to exposures $> 5 \times 10^{19}$ nvt has been concluded. This molybdenum differs from the lightly irradiated molybdenum used in previous annealing experiments since considerable line broadening is present after irradiation. Some conclusions concerning the influence of annealing on line broadening are: (1) line broadening persists to temperatures as high as 800 C; (2) line broadening (5×10^{19} nvt material) anneals out in two temperature stages, 50 to 250 C and 400 to 800 C; and (3) line broadening of 1.2×10^{20} nvt irradiated molybdenum can be completely recovered by annealing above 600 C - little change is seen below 300 or 400 C. It has been noted previously that all properties do not anneal in the same temperature ranges. Irradiation induced x-ray line broadening of 5×10^{19} nvt molybdenum is reduced by 30% in the temperature range between 25 and 250 C. No corresponding decrease in the irradiation induced lattice expansion occurs in this range. Subsequent isochronal anneals in the 300 to 400 C range reduce the residual expansion by 25%, while the extra line broadening decreases only by 5%. The two irradiation induced property changes measured by x-ray do not recover simultaneously in the temperature range between 25 and 400 C; above 400 C they do. There are other examples of varying recovery rates in other irradiation induced property changes in irradiated molybdenum. In this same neutron exposure range, annealing of excess electrical resistivity is found to follow a similar pattern to the line width, while microhardness and yield point increase with annealing above 100 C and up to 250 or 300 C. These changes illustrate the complexity of irradiation defect configurations.

quench and to compare the results of the oil quench with the results found in a nitrate quench. The following heat treatment was given all samples: 10 minutes at 730 C in NuSal, 20-second air delay before quenching, and quench into 20 C Houghton Quench "G" oil. Resulting grain sizes are about 0.130 mm in diameter and are fairly uniform; the results are comparable to those found in the heat treatments involving the 250 C nitrate salt quench. The samples have been sectioned for x-ray examination of grain orientation.

The first of eight 11-inch diameter by 11-inch long solid castings was processed for coextrusion billets. The casting was triple beta heat treated by heating in a chloride salt bath (LH 980) at 730 C for one hour soak time and quenching in agitated cold water. Time between removal from the bath and immersion in the quench varied between one minute, 15 seconds and one minute, 55 seconds. The billet was reversed between the second and third quenches. Final dimensional changes were approximately 0.050-inch increase in diameter at top and bottom, 0.010-inch diameter decrease in the middle and approximately 0.015-inch decrease in length. The ends were also slightly dished. The billet was machined to 11-inch diameter, the ends faced, and a 1.250-inch diameter hole drilled at the center. Primary extrusion was made by FPD with the billet wrapped with 0.020-inch copper. A reduction of approximately 8 to 1 was used. The primary extrusion is being machined to produce six 11-inch long coextrusion billets for vertical extrusion to N inner tube on the 700-ton press. The stock from these coextrusions are to be used in studying warp of the inner tube geometry during beta heat treatment.

Fuel Component Development. The rolls for the Three-Roll Straightener have been grooved to accommodate the increased diameter of the ends of brazed fuel elements. The relief has been cut to accept the 17.34-inch and the 23.13-inch long elements. Reassembly of the unit will be complete about January 30. Hot straightened elements will be subjected to long term autoclave cycles to determine amount of stress relief and rewarp.

Closure and Joining. Several welds have been made placing a bead of reactor grade Zircaloy-2 in a step cut on the outer diameter of both ends of a Zircaloy-2 round rod. The welding was done in a continuous flow, argon inert gas bottle to provide weld protection against the atmosphere. The object of these welds was to determine if a weld made by the Metallic Inert Gas process would pass the autoclave test. Autoclaving is now under way.

Another series of filler metal welds were made over the braze of the brazed fuel element closure. Micro examination of certain selected welds of this series has shown a bead of filler metal relatively free from braze material. Slightly excessive spatter and overhang was observed, but most of this can be eliminated by proper adjustment of the welding parameters.

Continued experimentation and destructive evaluation of the "Extrusion Closure" for Zircaloy-2 clad uranium fuel elements has led to the following conclusions:

1. Of the numerous bonding media tried, a 0.0005-inch copper electroplate on the Zircaloy cap-ring appears to give best results with respect to closure quality.

2. Under the conditions of processing, the copper plate alloys with the Zircaloy components to form a liquid or highly plastic alloy which flows into the free space between components and serves to bond them together wherever they are contacted.

3. When the dies and punches are arranged to cause actual coextrusion of the cap and side-walls, the latter are thinned by the metal flow, resulting in a more vulnerable product than when no extrusion occurs. Moreover, the extrusion causes blending and pressure-welding of cap and side-wall material only in the region of coextrusion and for a slight distance below this region.

4. The following changes in procedure appear to yield an improved product:

   a. The chem-milled grooves at the ends of the tubular Zircaloy-clad elements are shaped to an approximate 60° V. The cap rings are shaped to match and are copper plated to about 3/32" above the tapered part.

   b. The electron beam welding is modified to give about 0.050" deep penetration of the weld beads at both inner and outer lips.

   c. The die and punch sets are shaped to give a flat closure surface in the transverse plane at each end of the element.

5. These changes produce the following improvements in the process and product:

   a. The equipment and procedure are simplified and made amenable to production use. Both ends of the element may be pressed simultaneously.

   b. As the cap ring upsets and deforms to match the uranium face, the side walls and weld beads are also upset and compressed, becoming thicker and better consolidated.

   c. The V-shaped interface introduces a shear component into applied longitudinal tensile stresses, thus increasing the cap's resistance to mechanical separation.

Since the process has evolved to this form, the term "Extrusion Closure" is no longer appropriate and will be supplanted in future reports by the term "Self-brazing Closure" which more accurately describes the system.

Attachment of Zircaloy supports to Zircaloy clad fuel elements by resistance spot welding can generate a small area of slightly enlarged uranium grains immediately beneath the weld. Although this has not proven to be detrimental to the fuel element life, it represents a possible source of warp or instability. To determine whether this could be eliminated, a series of welds were made using the somewhat limited variables available on the 100 KVA Sciaky three-phase resistance welder. Preliminary examination indicates that the grain size changes can be eliminated by welding

Metallic Fuel Development

Fuel Irradiations. Two tubular NPR-type fuel element assemblies have been prepared for irradiation in the 6x9 loop of the ETR. This test is designed to determine effect of high temperature and an extremely high neutron flux on a closure brazed with the 12 Fe + 4 Be + 84 Zry brazing alloy. These elements will operate at a calculated power of 385 kw/ft with the inner elements producing 145 kw/ft and the outer tubes producing 240 kw/ft. The highest flux is 1,325,000 BTU/hr-ft^2 on the bore of the inner element and the lowest heat flux is 900,000 BTU/hr-ft^2 on the outside of the outer element. The maximum core temperature will be 669C on the inner element and the maximum jacket temperature will be 345 C. These elements are scheduled to run for one ETR cycle of six weeks starting February 13, 1961.

Production Test IP-300A, which consists of eight, 20-inch, natural uranium, Zr-2 clad, KER-size, tube-tube elements with projection welded end closures, has been discharged and shipped to Radiometallurgy. All of the elements are currently in Radiometallurgy basin awaiting visual examination and measurement of dimensions.

The first KER loading of enriched single tube NPR-type fuel has been discharged after attaining an exposure of 1200 MWD/T. These elements are 18 inches long, have Zr-Be eutectic brazed closures, and are supported by iron rails attached to the fuel element surface with Zircaloy-2 studs. During operation, the maximum fuel temperature ranged from 360-510 C, and the maximum power was approximately 150 kw/ft. The first 400 MWD/T exposure was attained with the loop on single pass flow using cold water.

During the course of the irradiation the delayed neutron activity in the loop doubled, but operation continued without incident. After discharging and reloading of the loop with brazed closure NPR inner tubes, the activity has returned to its previous normal level.

Basin examination of the discharged elements showed no obvious changes in the elements as a result of irradiation. The iron rails were black and showed no appreciable corrosion at discharge but are starting to corrode in the basin water. The fuel element surfaces showed some evidence of slight film formation. There was no apparent dimensional instability or swelling in the heat affected zone of the braze closures nor was there any discoloration or corrosion of the brazed closure. The elements will be weighed in the K basin for the direct determination of swelling behavior. In the interim the elements will be transferred for a more detailed examination at the C basin examination facility.

Two KER fuel elements are being examined in Radiometallurgy after 3350 MWD/T exposure. The fuel element containing unalloyed uranium has internal radial cracks in the fuel in both the inner and outer tubes. The alloy core (U-2 w/o Zr) element has been sectioned at mid-length; no cracks were found in either the inner or outer tube. An area of well-defined grain structure was observed in the unalloyed outer tube. Grain structure of this type had been seen previously only when uranium temperatures were above 600 C. The uranium fuel in this element was at a temperature of approximately 350 C

during operation. The measured density of the uranium fuel in the outer tube was 18.36 gm/cm^2. This amounts to a density decrease of 3.0 percent as the result of irradiation.

The tubular fuel elements of the fifth ETR rupture test have been received in Radiometallurgy and a visual examination has been made. The previously unirradiated test element was operated at full power for 2-1/2 hours after the defect cap was sheared off. The fuel element had swollen until the annulus between the fuel and basket was very nearly blocked, and the bore was partially blocked. The fuel element basket assembly was swollen in the region of the defect to an extent that it was not possible to readily remove the fuel elements. The outer Zircaloy-2 cladding around the defected area was found to be cracked and appeared to be brittle. The amount of uranium converted to oxide was estimated to be 1080 grams.

The space coordinates of the outer circumference of eight NPR inner elements were measured at six positions along the length of each element. These coordinates were measured after each processing step that could cause dimension changes. Four of the eight pieces were charged into KER Loop 4 on January 14, 1961. Post-irradiation examination of these elements will provide an opportunity to determine the effects of irradiation on the dimensional stability of these carefully characterized fuel elements.

A U-Mg fuel element has been examined at Radiometallurgy after an exposure of 15,000 MWD/T in the MTR. The 4.4-inch long and 1.12-inch diameter fuel element showed excellent dimensional stability, having grown only 0.002-inch in length and 0.004-inch in diameter. The fuel element stability was achieved by the use of 0.060-inch Zircaloy-2 clad which restrained the U-Mg fuel core. The core itself increased 0.006 inch in length and 0.006 inch in diameter and could not be removed from its can. Microscopic examination of the U-Mg core material revealed that the original spherical uranium particles have been greatly distorted, and the magnesium matrix material has accommodated this distortion by plastic yielding.

Failures of Zr-2 clad uranium rods and tubes as a result of localized clad straining have occurred in NaK capsule and high temperature recirculating water loop irradiations. Two recently examined fuel rods, from a series of Hanford capsules, have shown striations on the 0.020-inch cladding at 1100 MWD/T indicating that the cladding has started to neck locally. This observation indicates that non-uniform cladding thickness, such as exists in these rods, may be a more important factor than irradiation damage in causing the Zircaloy-2 cladding instability. The maximum circumferential cladding strain on these rods as calculated from dimensional measurements is 1.5 percent. Three other fuel rods, two with 0.020 and one with 0.030-inch cladding, at this same exposure show no indications of cladding striations. To further study the effects of cladding thickness variations on the susceptibility to failure, a series of NaK capsule irradiations of Zircaloy-2 clad fuel rods is planned.

Heat Treatment Studies. Five samples of NPR outer tube, extrusion 74 (25-mil inner and outer clad, 2.401 OD, 1.740 ID) have been heat treated to determine the degree of reproducibility available when using an oil

with the machine on single phase with a secondary voltage of 8.8. It is of interest to note that with the machine set to deliver a secondary voltage of 4.4 three-phase the grain size change could not be eliminated. The other conditions for welding without affecting the uranium are: element and support bright etched, class 2 electrode with a three-inch spherical radius, weld time 1/120 second with 35% phase shift, and weld force 350 lbs.

Fuel for Present Reactors. The 306 Building nickel plating facility was reactivated to provide plated cores for FPD to be used in their evaluation of pressure bonded and hot pressed fuel elements. Sufficient numbers of I&E, natural uranium cores are to be plated by the end of FY-1961 to provide approximately 300 of each type of bonded fuel element for reactor testing. FPD will perform the hot pressing while canned components are to be shipped to the Savannah River Works for fluid bonding.

Fuel Deformation Studies. A previous study of a fuel element model, which assumed a fuel material with a low yield stress and a cladding material with linear strain hardening, indicated that the cladding material could direct the swelling and thermal expansions of tubular fuel elements. Material tests for establishing a realistic estimate of fuel element cladding resistance have been proposed. Review of a new model for creep of anisotropic materials has been completed. A new fuel element model is being formulated which accounts for both the fuel and cladding materials behavior for a full temperature cycle.

Twenty-mil thick Zircaloy-2 jackets from coextruded fuel elements were burst under various conditions of stress biaxiality. In these tests the mode of fracture changed from a longitudinal to a transverse split when the longitudinal tensile stress was about 1.5 times the circumferential tensile stress. An unusual result of these tests was that, when the stress ratio was about 1:1, most of the straining was longitudinal; e.g., the longitudinal strain was 16 percent with a circumferential strain of only four percent.

In fuel elements with bonded end caps, a strain incompatibility exists between the fuel and end cap material. Past attempts at obtaining analytical estimates of the stresses in the end cap region of a fuel element were unsuccessful. Photoelastic techniques using embedded polarizers are now being investigated. Components for two fuel element models have been fabricated.

Facilities and Equipment. A second test has been made with experimental uranium scrap burning equipment. Even though there was a considerable increase in the weight of the batches burned, combustion of the metal progressed smoothly. The metal burned down to a fine powder and did so at temperatures which did not appear to exceed 1000 C. This low temperature may account for the fact that no clinkers are formed as is the case in most uranium fires. The design of the burner is such that it has a self-limiting effect on the rate of combustion. The constricted throat of the burner throttles the flow of air as the temperature of the charge increases. The previously stated hypothesis, that the time required to burn a batch of scrap would not be directly proportional to the weight of the scrap, has

been proven correct. A three-fold increase in the uranium scrap weight produced only a 2.2-fold increase in the time and a six-fold increase in Zr plus U scrap produced only a 3.6-fold increase in the time required for complete oxidation.

2. REACTOR PROGRAM

Coolant Systems Technology

Oxygen Scavenging with Sodium Sulfite. The dissolved oxygen scavenging tests using sodium sulfite in filtered Columbia River water have been completed. The following conclusions have been developed from a preliminary analysis of the experimental data:

1. The fraction of oxygen removed is directly proportional to the initial sodium sulfite to oxygen ratio.

2. The rate of reaction increases by a factor of 1.8 between 10 and 20 C.

3. The reaction rates for commercial and reagent grade sodium sulfite are identical within the limits of measurement.

4. The reaction rates are somewhat higher than those reported in the literature for similar water supplies and are lower than the rates measured in impure ocean water.

5. Cobalt ion in very low concentrations (0.1 to 10 ppb) is a very effective catalyst for this reaction.

Raw Columbia River Water Corrosion. The corrosion and scaling evaluation of a copper jacketed carbon steel heat exchanger tube in raw Columbia River water service has been completed. Heat was supplied by Dowtherm A at 630 F on the carbon steel side. Raw Columbia River water was heated from 50 F to ~ 130 F (temperature was dependent on the Columbia River temperature) on the copper side of the tube. A thin, black coating was found on the copper surfaces exposed to the water. Where the copper surface was exposed to air, a thicker, black, scaling oxide was found. A much thicker oxide was found on a control carbon steel heat exchanger tube which was in raw water service. The control also had numerous pits, presumably formed during several long shutdown periods when the steel was exposed to stagnant water. Heat transfer data are now being analyzed.

Corrosion samples of ASTM A212 carbon steel and X-8001 alloy aluminum have been charged into 310 F Columbia River raw water for a long-term corrosion test. Aluminum samples after two weeks of exposure did not exhibit any non-uniform corrosion, but several small pits one mil in diameter were found on the carbon steel.

Process Tube Technology

Examination of Zircaloy-2 Tube from KER-1. Burst tests were performed on two samples from the Zircaloy-2 tube irradiated in KER-1. These samples were

selected from regions near the center of the tube from which a sample had burst at 5000 psi. The burst pressures obtained of 16,000 and 16,500 psi correspond closely to the values of burst pressures for samples from the quarter points of the tube. Three samples from the front shield portion of the tube and one sample from the area that contained the heavy oxide layer on the inner surface were obtained for corrosion testing. A second sample from the area of heavy oxide was dissolved and a portion of solution was taken for radiochemical analysis to detect the possible presence of impurities.

Zircaloy Tubes for C Reactor. Two fabricators have undertaken the development of Zircaloy-2 tubes for the overbore test at C Reactor. One vendor with technical assistance from Hanford successfully produced and delivered nine tubes within nine weeks of the date of signing of the contract. Marked progress in tool design made during this period will eliminate a complete operation from subsequent processing. This development should have the effect of decreasing the cost of fabricating the tube and improving the quality. A second fabricator has encountered unforeseen difficulties and does not expect to deliver tubing prior to late February.

NPR Process Tubes. Differences continued to exist in the results achieved by the fluorescent penetrant test as applied at Harvey Aluminum Company and at Hanford. Many more indications are found on a given tube when tested at Hanford than were present on the same tube when tested at Harvey. The difference in results applies to both outside and inside surfaces of the tube. The results of the inside surface inspection may become more nearly comparable when Harvey replaces the present black light source on their borescope. The light they are using now contains an appreciable component of white light which may mask some of the fainter indications. They expect very soon to install a black light source identical with the one in use at Hanford. Some of the indications in the Hanford test have been found to be spurious. Contamination of the solutions is thought to be a contributing factor. A sample tube tested in the White Bluffs' facility is to be cross-checked in the 300 Area installation where cleanliness has proven to be excellent. Meanwhile, the tanks at White Bluffs have been emptied of penetrant and emulsifier, cleaned of rather severe sludge deposits and refilled with new materials.

At Harvey more than thirty tubes have been rejected because of small tears on the inner surface. Some of them can be removed by conditioning. In other cases the tube would be out of specification either on wall thickness or on inside diameter before the defect could be eliminated. Of the tubes presently affected, a disproportionate number appear to be from the bottom half of the original ingot. The cause of the difficulty is not yet known.

Nonmetallic Materials Development

NPR Graphite Irradiation. The GEH 13-5 experiment containing NPR reflector graphite is now in the third irradiation cycle in the N5 position of the ETR. The number three thermocouple failed during the recent extended shutdown and the heater at this position is now being manually controlled at the control point indicated by the thermocouple before failure.

Graphite Burnout Monitoring. Graphite burnout monitoring samples were discharged from channel 3461-B after 485 operating days. Average weight losses of samples upstream in the middle of the channel and downstream were respectively, 0.24, 1.71, and 0.05% per 1000 operating days. Samples have been prepared for an unassigned channel at KE Reactor which will supplement the regular 3066-KE monitoring during the production test to study the use of nitrogen as a constituent of the reactor atmosphere.

Irradiation Damage to Polycarbonates. The weight loss and gas evolution resulting from a series of gamma irradiations of polycarbonate plastics have been determined. The initial buildup of the oxygen concentration followed by a decrease at higher doses suggests that oxygen is first evolved which subsequently reacts with the polymer to form carbon monoxide and carbon dioxide. After an exposure of 3×10^8 roentgens, the weight loss of Lexan polycarbonate was 1.5%; the weight loss of Macrofol, a higher molecular weight material was about 0.5%. About 2.3×10^{-4} moles of gas having a composition of 60% CO, 35% CO_2 and 5% $H_2 + O_2$ were evolved from both materials.

Radiometallurgy Laboratory Studies

Rings from two long sections of tubing thought to be adjacent to Section No. 9, KER Loop I tube, have been examined, but no continuation of the oxide layer found on the No. 9 section was located. A small portion of tubing from the No. 9 section containing the oxide layer was dissolved for chemical analysis and an adjacent piece removed for corrosion testing. Four one-inch rings were cut from a low exposure section of the tube for corrosion testing. Burst tests were conducted on two sections of tubing suspected of being adjacent to the No. 9 section which failed at low pressure. Both pieces burst normally with a typical brittle fracture at approximately 16,000 psi (RM-330).

The results and interpretation of these examinations will be reported in more detail in connection with the development programs served.

Thermal Hydraulic Studies

Boiling Burnout Conditions for Eccentric Annuli. The program to investigate the effect on heat transfer conditions of the non-coaxial positioning of fuel elements within a coolant tube was continued. Collection of data applicable to I&E fuel elements in a K Reactor process tube was completed for the cases of 50% and 75% eccentricity. (Percent eccentricity is the fraction of the normal annulus thickness that the fuel element is displaced from a coaxial position toward the wall of the coolant tube.)

The test section used was a 24-inch long, electrically heated rod, 1.457" in diameter, placed within a 1.681" ID tube. Data were obtained for two flow conditions of cooling water through the annulus. These were 40 gpm at 107 psig and 23 gpm at 53 psig, which represent conditions in the flow annulus for I&E fuel elements in the central and fringe tubes at a K Reactor. The temperature of the water at the inlet of the test section was held constant during each approach to boiling burnout but was varied during the

investigation between 6 and 170 F below the boiling temperature. During each run, while the heat generation rate was gradually increased, temperature measurements were made of the heated surface and cooling water at selected points around the annulus of the test section. Each run was terminated when film boiling was encountered as detected by a large temperature excursion at some point on the surface of the heated rod. Some typical results are as follows:

	Flow Rate (gpm)	Water Temp. (°F below boiling pt)	Eccentricity (%)	Boiling Burnout Heat Flux (B/hr-sq ft)
Case I	40	60	50	1,150,000
Case II	40	60	75	530,000
Case III	40	130	50	1,450,000
Case IV	40	130	75	580,000
Case V	23	60	50	830,000
Case VI	23	60	75	420,000
Case VII	23	130	50	1,150,000
Case VIII	23	130	75	500,000

These data indicate that when fuel elements are not coaxially positioned within coolant tubes in the Hanford reactors, the boiling burnout heat flux is reduced to very near the normal operating heat flux of the fuel elements. This probably leads to high surface temperatures and, in some cases, ruptures of the fuel elements.

During the experiments boiling burnout generally took place at the very downstream end of the heated test section. However, it was noticed that sometimes a surface temperature higher than normal but lower than those associated with boiling burnout was encountered 2-1/2 inches further upstream. The temperature at this point would sometimes remain high all during the time heat flux was being increased to burnout conditions while on other occasions it would shift back to normal before burnout was reached. No explanation is offered for this behavior although it might be noted that this point was 2-1/2 inches downstream of a short spacing rib located in the flow stream.

Review of Outlet Water Temperature Limits for BDF Type Reactors. The report "Laboratory Data for Review of Outlet Water Temperature Limits for BDF Type Reactors," HW-67139, was completed and issued. The laboratory results update the knowledge of the thermal and hydraulics conditions for BDF type reactors during an inadvertent flow reduction. The data were obtained with a full size, electrically heated mockup of a charge of I&E fuel elements in a single process tube.

The results extended previous data to higher tube powers and, in addition, included an examination of the effects of high rear header pressures and low Panellit pressures on the ability of the reactor Panellit gage system to detect flow losses. This information is used in setting the reactor outlet water temperature limits.

It was concluded from the results that in principle the present method of calculating outlet water temperature limits was valid for the cases studied, but that slight modifications were advisable to improve the accuracy of the method. The report, HW-67139, discussed these modifications in detail.

Heat Transfer Experiments Pertaining to the NPR. The studies to determine the boiling burnout conditions for the NPR tube-in-tube fuel element were continued. Experimental data were obtained in the heat transfer laboratory which are applicable to the middle flow annulus of the fuel element.

The test section used consisted of two 24-inch long coaxial tubes, the larger having an ID of 1.775 inches and the smaller having an OD of 1.220 inches. Both tubes were electrically heated and all of the heat generated was transferred to water flowing through the annulus formed by the two tubes. Thermocouples attached to the walls of the two tubes were used to detect the temperature excursions associated with boiling burnout conditions.

Boiling burnout data were obtained at 1500 psia for flow rates between 0.5×10^6 and 4×10^6 lb/hr-sq ft, and inlet water temperatures ranging from 510 to 585 F. The burnout heat flux for these conditions ranged from 400,000 B/hr-sq ft at the lowest flow rate to 1,620,000 B/hr-sq ft for the highest flow rate and lowest water temperature. Data were obtained for conditions of bulk boiling as well as subcooled water at the point of boiling burnout.

The data reported here will be combined with results from previous and future experiments to verify the fuel element design conditions and establish the maximum operating limits for the reactor.

Evaluation of Experimental Data. A system was developed to expedite the analyses of the boiling burnout data obtained on the experimental heat transfer apparatus by using the facilities of the Data Processing Center. Two separate computer programs were written to accommodate data from any of the variety of burnout test sections being used. By recording the various instrument readings directly on special forms during the experiments, the data can be transcribed directly onto IBM cards for processing on the 7090 computer. The following items will be automatically calculated:

1. The heat flux for the various heated surfaces.
2. Inlet and outlet temperatures from thermocouple readings in millivolts.
3. Flow rates from venturi pressure readings.
4. Enthalpy and quality of the fluid at the outlet of the test section.
5. Heat balance.
6. Temperature of the heat transfer surfaces.

It is estimated that the results from the experiments will be available within two days of its gathering and will greatly reduce the amount of hand calculations that are normally required.

Hydraulic Studies. One of the zirconium process tubes procured for the overbore program at C Reactor was installed in the hydraulics laboratory and equipped with inlet and outlet piping connectors identical to those fabricated for use on the reactor. The tube was charged with 32 C VI I&E self-supported fuel elements and pressure drop-flow data were collected for verification of the hydraulic design conditions. The fuel elements were 1.989 inches OD and 0.344 inches ID and the process tube was 2.144 inches ID.

It was found that pressure drop across the fuel elements at 50.5 gpm was 237 psi as compared to a design value of 270 psi. This deviation is within the accuracy to be expected from existing theoretical equations and can be compensated for by increasing the pressure drop across other components of the tube. The ratio of flow through the annulus to flow through the hole of the fuel elements was found to be 2.91 compared to a design value of 2.75. This means that the temperature of the coolant water in the hole will be slightly warmer than desired for optimum operating conditions.

Shielding Studies

Shielding Instruments. The source of the unexpected energy peaks observed in the recent analysis of the $Be^9(d,n)$ reaction is not yet known. They are believed to be due either to carbon (d,n) reactions or to a new excited state of Be. Time of flight measurements will be made in the ion accelerator laboratory in an attempt to resolve this difficulty. Plans have also been made to eliminate the possibility of carbon contamination by fabricating new clean beryllium targets for the accelerator.

Attenuation Studies. A new method for calculating neutron, gamma, and heat distributions in shield materials is being investigated for application to shielding problems of interest at HAPO. The computer program, developed by A. F. Avery (AERE-R-3216), is being rewritten for the 7090 computer. The first use of the program will be an attempt to reproduce the experimental data obtained for several concretes in the DR Reactor test wells.

B. WEAPONS - 3000 PROGRAM

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

C. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Plutonium Fuels Development

PRTR Fuel Fabrication. Thirty-one Mark I-H plutonium spike fuel elements for the first PRTR power tests were completed in January. These Class I fuel elements and the six completed in September total thirty-seven clusters available for full power use. The Mark I-H design uses the CSO (Al, 1.8 w/o Pu, 2 w/o Ni) corrosion resistant alloy and 35-mil wall Zircaloy-4 sheath tubing. All of these clusters use a Zircaloy-4 hanger adapter (Dwg. No. H-3-13937) designed to prevent the interchange of the uranium oxide and plutonium-aluminum fuel elements from their respective hanger rods.

The special physics fuel element Experiment No. 1 (Dwg. No. H-3-13332 and H-3-13333) using Lutecium foils was completed in January and delivered to PRTR.

Cores, tubes, and hardware are being prepared for the next twenty-eight plutonium spike fuel elements to be used as replacements at the rate of one per week after the PRTR reaches full power. The completion date on these twenty-eight clusters plus spares is April 1961.

Fabrication Development. Uniform distribution of PuO_2 in UO_2 is required in the uniformly enriched oxide elements. For simplicity in a swaging process, it is desirable to add PuO_2 as the fine "powder" normally available, rather than as an arc-fused UO_2-PuO_2 solid solution which must be crushed and sized. However, in loading the Zircaloy tubing with UO_2-PuO_2 mixture, use of a vibrating table to reach the desired tap density may cause differential settling with resulting "segregation" of the PuO_2 particles. Several alternative solutions to obtaining uniform distribution are available; one of these is tamping. One tube was hand-tamped with UO_2 to approximately 98 percent of the tap density achieved by loading with a 60-cycle vibrating table. A screen analysis was made to determine the distribution of the fines (-325 mesh) in ten sections throughout the length of the tube. In nine sections the fines comprised 10 to 13 percent of the UO_2 and in the bottom section the fines comprised six percent of the UO_2. With improved blending techniques, hand-tamping may provide a feasible alternative loading method for obtaining uniform UO_2-PuO_2 distribution. Alternatively, electronic vibratory compaction equipment may be used, with or without final swage reduction.

The nondestructive measurement of PuO_2 distribution in swaged or vibratory compacted UO_2-PuO_2 fuel rods is required for the fabrication of the uniformly enriched loading for the PRTR. Gamma spectrometer studies by Instrument Research and Development Operation are under way for this purpose and a Zircaloy-clad capsule containing PuO_2 pellets has been supplied for evaluation. Two additional capsules containing UO_2-PuO_2 are also being prepared to support this study.

Reduction of zirconium scrap to a homogeneous metal by mechanical hot working has shown favorable results. Specimens reduced 85 percent at 850 C were given various heat treatments after reduction. Heat treatments were investigated by metallographic examination to determine the extent of diffusion of incremental particles that had been hot-reduced together. Specimens heated in a vacuum at 900 C up to twenty-four hours showed very little diffusion. Above twenty-four hours there was partial diffusion. One sample given a heat treatment of one hour at 1200 C showed almost complete diffusion. This specimen was given the standard steam autoclave corrosion test. Results of the test were favorable in that the scrap from which the specimen was made had not been chemically cleaned before reduction. The corrosion rate was just twice that of acceptable specification. Zirconium scrap chemically cleaned and reduced to 95 percent is now in process of investigation.

Development of Zircaloy roll-clad, plutonium-bearing extended surface fuel elements continued. Bonding between Zr-Zr sandwiches was reproduced at rolling temperatures of 750 and 800 C and reductions of 90-95 percent. Complete bonding is apparently obtained with the exception of a one-fourth inch wide strip along each edge; one Zr-Zr sandwich was rolled without outgassing with complete bonding being obtained except for the edge. Six attempts were made to roll a Zr-Zr sandwich containing a Pu wafer; however, in each case the steel container cracked at a weld. In order to prevent a spread of contamination, rolling was stopped when the crack appeared. New containers with better weld joints are being designed to alleviate the problem.

A three-foot long, seven-rod injection-cast cluster is being prepared for ETR irradiation. Samples from the ends and center of rods cast from DSO alloy (2.5 w/o Pu, 2 w/o Ni, bal. Al), which is required for the irradiation cluster have been non-uniform in plutonium composition. The tops and centers of five 88-inch long castings were reported to be above the tolerance of $\pm$ 5 percent of the nominal composition while the bottom ends of the castings were below the tolerance. Effective means of obtaining complete liquid solution of the alloy before injection into tubing have not been determined. Manual stirring appears to be more effective than holding at 800 C for thirty minutes or than bubbling nitrogen gas at the bottom of the melt crucible for ten to twenty minutes. Five castings were produced without surface oxide on the cladding. This was accomplished by evacuating a 1/16-inch wide annular space around the tube prior to casting.

Experiments with sintered aluminum powders are in progress to observe the effect of these higher hot strength materials on thermal cycling of Zircaloy-clad fuel rods. SAP rods will be prepared from atomized aluminum powder and from flake aluminum powders of three sizes: 0.8 μ, 0.4 μ, and 0.17 μ. To date, rod from only the atomized powder has been extruded. Tensile tests at room temperature gave a Y.S. of 14,300 psi, which is about twice that of the aluminum-plutonium core alloy. Thermal cycling specimens are now being prepared.

Fuel Evaluation. The four-foot long Zircaloy-clad seven-rod cluster containing 1/2-inch diameter sintered and ground UO_2-PuO_2 pellets is continuing irradiation in the 3x3 loop. It now has an accumulated exposure of about 55 full power days or the equivalent of about 1760 MWD/T. The element is operating with a maximum core temperature of 1850 C with an associated surface heat flux of 346,000 BTU/hr-ft^2. It is receiving additional exposure.

The 42-inch long seven-rod Al-Pu cluster which was subjected to 65 thermal cycles plus seven reactor scrams in the ETR 3x3 loop is being examined at HAPO. It was cycled under PRTR conditions over a temperature differential of 300 F at a heating and cooling rate of 5 F/min. No warping or bowing of the assembled seven-rod cluster was detected in the hot cell. The Zircaloy bands and the helically wrapped spacing wires remained tight following the cycling treatment. There was indication that the cluster design was functioning properly and that independent expansion and contraction of the individual rods had occurred. It appeared that the center rod had expanded more, relative to the rods in the six-rod ring. Warp measurements were made on the rods over a 36-inch gage length, and the results are as follows:

Al-Pu 7-Rod Cluster Thermal Cycling Experiment

Rod No.	Warp (in.)	Graphite Coated Cores
1	0.010	Yes
2	0.039	Yes
3 (center rod)	0.106	No
4	0.051	Yes
5	0.055	No
7	0.043	No
10	0.051	No

Rods numbered 1, 2, and 4 contained cores which were coated with graphite in order to determine the possible effect of such a lubricant on their thermal cycling behavior. The warp measurements do not indicate any particular differences as a result of the graphite lubricant. Length and other rod measurements are being taken at the present time.

The seven-rod Al-Pu cluster rupture element has been completed and shipped to the ETR for testing. It is presently scheduled to be charged into the ETR on about February 20. This element has a brazed rupture tip which will be broken off while the element is operating, thus exposing a 0.035-inch diameter unreinforced hole in the 0.035-inch thick Zircaloy cladding. The test proposal is now being considered by the MTR/ETR Reactor Safeguards Committee.

The eleven irradiated UO_2-PuO_2 capsules have been visually inspected, photographed and measured. The specimens all appear to be in very good condition. Present exposure is on the order of 5000 MWD/T. Arrangements are in progress to recharge the pieces into the MTR for additional irradiation. Current plans are to set the goal exposure at 10,000 MWD/T.

The two capsules (GEH-14-27, 28) fabricated with Al - 2 w/o Ni - 1.9 w/o Pu alloy cores by injection casting were shipped to the MTR in January 1961. The Zircaloy-clad specimens are 0.55-inch in diameter and 3.6 inches in length.

The post-irradiation examination of the six PuO_2 impregnated graphite capsules which were irradiated in the MTR is being conducted at Hanford. External dimensional measurements were unchanged as a result of the irradiation. Fission gas samples have been taken; however, the data have not yet been completely analyzed. The total amount of gas released from each capsule is given below:

Sample No.	Requested Operating Core Temp. (Max.) (°C)	Requested Burnup (% Pu Atoms)	Gas Volume (Total)
GEH-14-13	778	25	3.46
GEH-14-14	778	50	3.80
GEH-14-15	525	25	3.17
GEH-14-16	525	50	3.04
GEH-14-17	345	25	2.45
GEH-14-18	345	50	2.74

There seems to be a correlation between the requested calculated core temperatures and the total amount of gas released. Also, in two of the three sample pairs, more gas is released for the higher burnup samples. A more complete analysis will be made using the actual exposures from the flux wire data.

An examination of the graphite cores indicates that they have swelled; in some cases apparently filling the 0.020 inch diametral gap on a 1/2-inch diameter sample. The examination is continuing, and a more detailed analysis of the data will be made.

All the samples for the Phoenix capsule experiment have been made with the exception of the two fission standards which will be completed shortly. Reactivity measurements on the capsules will then be made in the PCTR prior to shipment to the MTR. The capsule holders and RMF lattice assembly are complete, and the test proposal is being written. Irradiation of the first sample should begin in March.

Preliminary physics calculations on the PuO_2-UO_2 experiments in the SNOUT facility indicate that 305 Reactor tests would be highly desirable in order to more accurately determine actual in-reactor variables. Work is in progress to design and fabricate a mutually acceptable test element for the in-reactor physics experiment. The enriched material for the irradiation tests has been requested and bids received by the AEC, but the order has not been placed yet.

Facilities. Requirements for the FRPP refabrication cell have been tentatively established, and scoping studies for design purposes are under way. A number of layouts have been made on the basis of integrated reprocessing and refabrication cells. Additional layouts are being made

on both integrated and non-integrated cells to establish the design and operational problems presented by each concept.

A number of facility modifications and additions have been performed during the past month. These include installation of a new wire wrapping machine and an increased capacity pumping system for the vacuum welding box, modification to the demineralized water system suggested by the vendor's field engineer to improve water quality and reliability, and training of all 308 Building personnel in the use of the emergency fresh air masks recently obtained.

UO_2 Fuels Development

Fabrication Development. Bulk densities of 94.5-95% T.D. were achieved by hot swaging fuel rods consisting of -60 mesh fused UO_2 contained in 0.015-inch wall 304L stainless steel sheathing. These fuel rods were heated in an induction heating coil to approximately 900 C as they entered the swage. The induction heating coil continued to exhibit excellent heating characteristics. Temperature fluctuation during operation is less than ± 25 C. Modification of the fuel rod loading procedure has eliminated the problems associated with hot spots which occurred near the ends of the fuel rods during heating. The process now consists of (1) welding an end cap on one end of the sheath tubing, (2) loading the tubing with UO_2 to within 1/8-inch of the top, (3) inserting a disk of 100 mesh screen to contain the UO_2, and (4) welding an end cap on the top end of the loaded tube. The welds are made by the magnetic force welding process. During welding of the second end cap, the loaded tube is evacuated and backfilled with helium. The closed fuel rod is cold swaged to approximately 0.675 inch OD, then hot swaged to approximately 0.566 inch OD.

Fuel rods prepared by this technique have presented no problems during either cold or hot swaging. The presence of UO_2 completely along the fuel rod serves to conduct heat uniformly from the cladding. Thus, no severe hot spots occur. No evidence of cracks or failure of the welds made with the magnetic forcer welder was found after swaging.

Three 18-inch tubular fuel elements fabricated by vibrational compaction for testing in a KER loop were autoclaved in steam for 72 hours at 1600 psig and 310 C. Two of the elements revealed some contamination near the weld area, at one end, and will be re-etched and autoclaved.

Plans for PRTR power tests utilizing thermocoupled, swaged UO_2 fuel elements were submitted and approved. These tests reflect common interests of RFRDO and PIRDO.

The fuel rods were swaged with a stainless steel clad thermocouple at the center of each rod. The thermocouple extends out of the center of the end cap at the top of the fuel rod. Zircaloy end caps are welded into each end of the Zircaloy clad fuel rod. A Zircaloy-to-stainless steel diffusion bonded transition joint is provided in one end cap, with the final closure being completed by brazing the thermocouple cladding to the stainless steel section of the end cap.

Demountable, foil-containing, swaged UO_2 fuel elements were supplied for PRTR critical tests.

Fuel Irradiations. The fuel cycle was "closed" January 16, with the successful re-irradiation of UO_2 in the GEH-4 facility of the MTR. The remotely fabricated fuel element contained one rod of recycled UO_2 decontaminated of major nuclear poisons via the "salt cycle" process developed by the Chemical Research and Development Operation. The element was discharged from the reactor after an exposure of approximately 700 MWD/T at a maximum surface heat flux on the Zircaloy cladding of 600,000 BTU/hr-ft^2. In addition to the recycle fuel rod, the cluster element contained two other rods with electrodeposited UO_2 (not previously irradiated) and a fourth, used as a standard, with sintered UO_2 pellets. All of the fuel was 1.6 w/o enriched. The fuel element is being returned to Hanford for post-irradiation examination.

A purposely defected, vibrationally compacted, UO_2 fuel rod with both Zircaloy-2 and Zircaloy-4 cladding (two tubes butt welded together and defected with a 0.006 inch diameter hole at the junction) was irradiated to compare the hydriding rates of Zr-2 and Zr-5. Post-irradiation studies reveal:

1. The splitting of the Zr-2 and Zr-4 occurred by ductile fracture, rather than by deterioration of the cladding by excessive cladding temperatures or hydriding.

2. No significant hydriding occurred in any part of the Zr-2 or Zr-4.

3. Evidence of high localized temperatures in the Zr-2 was found downstream from the failure near the weld.

4. The small areas of localized temperature were also associated with diffusion reactions between the UO_2 and Zircaloy.

Additional defect tests are scheduled.

The first irradiation of high energy impact formed (H.E.F.) UO_2 began January 16. The fuel material had a particle density greater than 99% T.D., and was vibrationally compacted to a bulk density greater than 90% T.D. The fuel is contained in a standard MTR-ETR capsule. Irradiation in the core of the ETR is continuing with a maximum power generation of 60 kw/ft and a maximum heat flux of 1,350,000 BTU/hr-ft^2 on the surface of the Zr-2 cladding. Objectives of the continuing test are to obtain fission gas release data and to determine grain growth characteristics and in-reactor sintering behavior of this novel fuel material. Post-irradiation studies also will include electron microscopy.

The irradiation test of an assembly of thin-walled, stainless steel clad, vibrationally compacted UO_2 fuel rods continued in the VBWR without unusual incident. The nine-rod cluster, VBWR-2 (referred to as HAPO-2 by APED) performed as planned, at a maximum surface heat flux of approximately 350,000 BTU/hr-ft^2.

Closure and Joining. A newly installed arc welding fixture has provided an excellent means of positioning very thin sections of material to perform weldability investigations. Welds were successfully made on fourteen 0.010-inch thick sheets of various nickel alloys and stainless steels.

Closure welds were completed on sections of 0.563 inch OD by 0.010 inch wall 406 stainless steel tubes. Two methods are being evaluated: (1) resistance butt welding and (2) tungsten arc inert gas welding. Internal pressure tests and metallographic examinations are being performed to evaluate the welds.

A Visocorder trace of the input line voltage, welding current and the voltage drop across the weld joint is being investigated as a means of accurately monitoring the magnetic force welding process to visually depict any irregularities in welding parameters. One percent variations in the welding current and voltage can be identified on the Visocorder trace and used as a quality measuring test for the weld. This monitoring procedure may be used either during the weld or as a test after welding by measuring the current and voltage drop of a second pulse of current across the welded joint.

Fuel rod spacer ribs of various shapes have been used to determine which configuration will produce the highest quality weld between the rib and fuel rod cladding. The primary factor in determining the quality of Thermotool welds is the ratio of weld width to total contact width. A ratio of one has not been reached, but recent tests made with 0.005" to 0.075" contact widths gave the following results:

1. Contact widths greater than 0.050" cannot be welded.
2. There is no apparent advantage to widths less than 0.015"; however, widths down to 0.005" can be welded.
3. Contours such as oval wires or wires scarfed to a matching radius of the tube diameter may increase the weld to contact width ratio.

Corrosion Studies

Effect of Oxygen on Corrosion Product Hydrogen Pickup. An experiment initiated last month to test the hypothesis that the oxygen content of the water may be the controlling factor for corrosion-product hydrogen pickup for Zircaloy-2 and -4 during autoclaving has been completed. It was shown previously that the percent of hydrogen pickup in a static autoclave system (< 0.1 ppm oxygen) was twice as great as in a refreshed autoclave system (3 to 4 ppm oxygen).

The completed test consisted of autoclaving a series of Zircaloy-2 and -4 coupons in a refreshed 400 C deoxygenated system for various lengths of time and evaluation of the percent of hydrogen pickup at the different time intervals. The data show that the percent of hydrogen pickup for Zircaloy-2 and -4 in a refreshed deoxygenated (< 0.1 ppm oxygen) autoclave system is higher than in a refreshed system containing 3 to 4 ppm

oxygen and more closely resembles the hydrogen pickup in a static autoclave system. The percent of hydrogen pickup in the refreshed deoxygenated system was 28% for Zircaloy-2 and 20% for Zircaloy-4. The previous results obtained in static and refreshed systems were 30% (Zr-2) and 28% (Zr-4), and 15% (Zr-2) and 13% (Zr-4), respectively.

Aluminum Alloy Development. Aluminum alloys containing 1.0% Ni, 0.5% Fe, and 1.2% Ni, 1.8% Fe with varying silicon contents have now been in test in 290 C deionized water for two months. None of these alloys show better corrosion resistance than X-8001 at this temperature and after two months of exposure, many of them are blistering.

The alloys in which blistering is most severe are those which have the lowest silicon content. Annealing of some of the severely blistered alloys has been started to determine if this will alleviate the blistering.

Corrosion of Ceramic Coated Aluminum. Samples of X-8001 aluminum alloy with ceramic coatings of ZrO_2 and Al_2O_3 were corrosion tested two weeks at 300 C in water at pH 6 to 7. At the end of the exposure period, the ZrO_2 coating had been completely removed, but the Al_2O_3 coating was still intact. Aluminum without a ceramic coating corrodes at such a high rate under these conditions that a natural protective oxide is not formed. The tests are continuing to determine weight changes.

Fretting Corrosion. The low-temperature test was terminated in CEP-2 after 1107 hours at 20 C and a pH of 10.0. Final results on the vertical fretting assemblies revealed penetrations of ~0.5 mil on the components exposed to natural loop vibration and one to four mils on the components subjected to an additional three cps. Under identical conditions at 316 C the samples with no external vibration corroded two mils and those subjected to an additional three cps corroded five to ten mils. The mechanism of fretting would appear to include both wear and corrosion. Another test at 316 C has been started to determine if mild steel supports will cause fretting in Zr-2 tubes.

Aluminum Corrosion. An improved aluminum alloy, A-288 (Al, 1.0 Ni, 0.5 Fe, 0.1 Ti, low Si) was compared with X-8001 in the ELMO-6 Loop. After 1100 hours at pH 6-7 and 300 C, both alloys appeared to corrode at similar rates. This is in contrast to the data obtained by Argonne National Laboratory in their dynamic loops at 315 C. It thus appears that A-288 corrodes at a lower rate than X-8001 at temperatures above 300 C, but below 300 C the corrosion rates of A-288 and X-8001 are the same. Thus, in a pressurized water reactor in which the temperature is at some point less than 300 C, the A-288 alloy is not an improvement over X-8001. Because the corrosion rates for X-8001 at 300 C are too high at pH 6-7, A-288 can also not be used in a pressurized water reactor under these conditions.

It has been hypothesized that aluminum corrodes rapidly in deionized water because some corrosive ion is present and that this corrosive ion is probably silicon leached from the steel. To test this hypothesis, some additional steel ballast was added to the tests described above. The corrosion rates did not increase as might be expected if this hypothesis were true.

Structural Materials Development

Process Tube Monitoring. Following the hot test of the primary coolant system of the PRTR in December, the inside diameter of the Zircaloy-2 pressure tubes and the insulating gas gap between the pressure and shroud tubes were measured. The gas gap for several of the tubes was appreciably less than the nominal 1/4" specified. The smallest gap measured was 0.1". A series of tests performed in a mockup tube revealed that the gage is unaffected by the presence of shim rods or magnetic materials external to the aluminum shroud tube and that ellipticity or bowing of the aluminum shroud tube would give results similar to those found in the tube with the smallest gap.

Radiation testing of optical grade glasses and plastics has been completed to a total gamma radiation of 5×10^9 R. Purified fused silica was found to be most radiation resistant and virtually unaffected at this dosage. Radiation protected borosilicate crown was slightly superior to dense flint glass although both have good resistance to radiation darkening. A Nuvista (RCA trade name) electron tube was unaffected by a gamma dosage of 10^8 R.

The combination of a non-radiation resistant TV camera and a borescope is a potentially cheaper solution to the problem of visually examining the inside surface of Zircaloy-2 process tubes in place in a reactor. Previous experiments have indicated that the intensity of the light received through a borescope is too low to be recorded on a TV camera. However, recent development of a special wide angle borescope lens and a low light level vidicon tube for a TV camera may form a workable system. The four proposals for the development of a radiation resistant TV camera were reviewed, but action will be withheld pending investigation of the above combination.

Zircaloy Sheath Tube Program. A chronic problem in the fabrication of thin-wall Zircaloy sheath tubing has been the presence of impressed foreign material on both the inside and outside surfaces of the tube. The following observations are the result of a continuing review of the quality of tubing received. The efforts on the part of the fabricator to clean up his process have caused a marked decrease in both the frequency and severity of impressed particles. Of 30 samples selected from the last 500 tubes received, one contained two cracks 0.6-mil deep associated with impressed material. The maximum depth of the impression caused by impressed material in this group of tubing was 3.5 mils with an average depth of two mils. The contour of the impression was smooth rather than sharp at the corners. In those instances where the impressed particle has been removed, the pit or impression is detectable only by white light borescoping. When the impressed material is still in place, white light borescoping and, in some instances, black light borescoping can detect its presence. X-ray microscopy and emission spectrography indicate that in every case tested the impressed material proved to be zirconium. Apparently the manufacturer is not cleaning the tubes sufficiently subsequent to cutting operations. He has been apprised of the situation and promises to take immediate action to further clean up his process.

Alloy Evaluation Program. A preliminary screening study of a number of potential cladding and pressure tube materials has been in progress, encompassing determination of fabricability, weldability, and in-reactor service behavior of selected iron- and nickel-base alloys. The preliminary data obtained, which are summarized in HW-67715, led to the following provisional conclusions:

1. Hastelloy X, preferably without cobalt, is the most suitable one of 21 iron- and nickel-base alloys evaluated to use as structural material in dry carbon dioxide of moderate pressure at 1500 F (816 C), the design operating condition of the PRTR gas loop.

2. AISI 304, 316, 347, and 446 stainless steel, listed in order of increasing resistance, represent those of the alloys tested which are least affected by pure, deionized water of pH 7 at 360 C (680 F) and 3200 psi pressure. In deionized, deoxygenated water of pH 10 at 290 C (554 F) and 1500 psi pressure, Hastelloy X offered the highest resistance in addition to the above mentioned stainless steels.

3. In these simulated reactor environmental exposure tests, the preceding top rated alloys were followed in corrosion and oxidation resistance by the iron-chromium-aluminum base alloys, including the AISI 406 stainless steel.

To conclude the alloy evaluation program, Hastelloy X and 406 SS, possibly with Inconel and 306 or 347 SS for comparison, will be subjected to further examinations of:

1. Effects of neutron irradiation.
2. Resistance to superheated steam.
3. NaK - compatibility.
4. Diffusion bonding and heat transfer.
5. Tube burst testing.
6. Fabricability and weldability.

Radiometallurgy Laboratory Studies

Examination of GEH-4-54, defected, vibratory compacted UO_2 fuel rod, revealed the following:

1. Bursting of the cladding was caused by internal pressure rather than by heating or deterioration by hydriding.

2. Although the water flow was restricted, it was not completely stopped as attested by the state of the Zircaloy-2 cladding downstream from the rupture.

3. No hydriding occurred in any of the Zircaloy-2 or Zircaloy-4 cladding even though small areas of three samples were heated to the recrystallization temperature of Zircaloy-2 and Zircaloy-4. (RM-619)

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

Thermal Hydraulics Studies

Fuel Element Temperatures in Fueling Vehicle. A general method of determining surface temperatures of a heated element in which the heat generation rate varies longitudinally in accord with a chopped cosine function and which has axial coolant flow was developed. The method locates the hottest surface point and determines the magnitude of the temperature. The magnitude of the surface temperature depends upon the peak to average heat generation ratio, the total heat generation, the geometry of the element and coolant flow rate. The location of the hottest point depends upon the peak to average heat generation ratio and on the term WC_p/LhA, where

W = coolant mass flow rate
C_p = heat capacity of coolant
L = length of heated element
A = heat transfer area per unit length
h = heat transfer coefficient.

Small values of WC_p/LhA move the point of maximum surface temperature toward the downstream end of the element.

Application of the method to determine the surface temperatures of PRTR fuel elements in the fueling vehicle is in progress. This is an extension of previous work to different peak to average heat generation ratios. For air cooling of PRTR fuel elements, the term WC_p/LhA was found to be so small that the maximum temperature occurs at the downstream end of the fuel element.

PRTR Project Management and Design

PRTR Construction. Phase III-A (construction items not completed by the Phase III contractor or not included in his contract) being completed by J. A. Jones, is estimated to be 92% complete.

The Maintenance and Mockup Facility (including the Rupture Loop Annex and Critical Facility Building) is estimated to be 33% complete versus a scheduled 39% as of January 31, 1961.

Concrete footings for the M&M Facility are being poured. The concrete roof slab for the Rupture Loop Annex was poured and the ion exchange vault is complete except for piping and painting. The first and second concrete pours for the Critical Facility were completed.

Beneficial use of the PRTR stack filter was obtained during January. A new exhaust fan and permanent inflatable seal have been ordered.

Phase III-A construction items on the primary system are scheduled to be complete at month's end. Temporary strainers were removed from the primary pump suction lines and gate valves welded in place. Temporary connections

to the system have been removed and final tie-ins to the cleanup system completed. To eliminate the high stresses at the pressurizer inlet nozzle resulting from pipe expansion reactions and thermal stresses in the bi-metallic weld, it was decided to alter the pressurizer nozzle to increase its flexibility. A new design and code calculations were prepared and have been approved. The alteration consists of removing metal from the pressurizer nozzle and replacing it with a reinforcement saddle welded on the shell of the vessel. The vessel will be stress relieved afterward. Work is being performed by FPD Maintenance.

The low pressure helium compressors in the reactor have been run briefly for vibration analysis. It was found that piping vibration was quite severe; however, the maximum vibration of the compressor platform reached a maximum of only 0.007 inch, which is not believed unusual. A Phase III-A item has been issued to install flexible metal hose sections in the compressor piping and to reinforce flexible areas in the compressor platform beams. Other work performed on the helium system included preparation of procedures for completion of helium dry gas system testing and cleaning, preparation of hydro test and air blow procedures for the high and intermediate pressure helium piping, and work instructions for vibration compensators on low pressure helium compressors and piping.

The installation of the mechanical portion of the fuel rupture monitor system is still not complete. Delays have been caused by higher priority work and late delivery of certain materials required for changes requested by construction forces. Piping connections are to be completed before power tests begin.

The electronic portion of the fuel rupture monitor system is to be delivered by the end of January. The manufacturer was declared in default on the contract because of failure of the equipment to pass acceptance tests after repeated attempts and considerable delay. The major difficulties with the equipment are in the scanning switches and recorder mechanisms. High contact resistance in the input scanning switch appears to prevent passage of the photomultiplier output pulses, occasionally resulting in a low signal alarm condition. The trouble is intermittent, occurring only a few times each day, but would prove very annoying in operation. The manufacturer is to furnish a new input scanning switch to be installed locally. This switch is to have gold plated contacts which should reduce the contact resistance problem. It is not known at this time what additional changes may be required to get the electronic system to operate satisfactorily. The manufacturer is to be responsible for the cost of any such changes.

No further significant difficulties have been experienced with the PRTR high level safety amplifiers since circuit modifications were made in all units. These circuit changes were the reduction of the amplitude of the self-checking test pulse by a factor of three and a lowering of the output impedence of the last stage of the amplifier section. In addition, a capacitor was added to each unit to simulate the ion chamber and cable capacitance in the calibrate position. This assures that the trip point will not change between the operate and calibrate positions. Such changes

had been experienced in operation with the trip coming at lower power levels during operation than when calibrated.

Isolation relays have been installed in all period trip circuits in the safety system. It has not yet been determined whether these have eliminated all "sympathetic" period trips which were occurring every time any other safety circuit trip occurred.

Phase III-A alterations to the fuel handler were scheduled to be complete at the end of the month.

The decking of the loadout trailer has been completed. The heat exchanger unit is being installed. Teflon inserts are being installed on the bearing surface of the tipping saddles to avoid galling of the cask trunnions. The loadout facility monorail extension has been completed.

Final acceptance testing of the manipulator of the Fuel Element Examination Facility has been scheduled for the first part of February. An installation package has been completed and submitted to J. A. Jones for estimating.

PRP Critical Facility (Project CAH-842). Design of the facility is complete with the exception of any revisions which may be required by the hazards analysis. The instrument procurement package, including the drawings, is being circulated for approval.

Status of development components to be mocked-up and tested on site is as follows: (1) Synchro transmitters and receivers for the control rod position indicators have been selected and the order is being placed. Approximately three-month delivery is expected. The same system will be used for weir position indication. (2) Safety rod design is now being detailed. Except for details concerning the magnet installation, this design is scheduled for completion in about two weeks. (3) Weir, thimble and source positioner designs are all complete to the stage where initial fabrication may be started. Completion dates for testing purposes are scheduled as follows: source positioner, March 1, 1961; thimble, April 15, 1961; weir (excepting position indicator), April 1, 1961. Preliminary tests indicate that fuel element weight will adequately seat the O-ring seals on the top of the reactor vessel.

Construction of the facility continues with the placing of the concrete for the lower portions of the cell. The George Grant contract is estimated to be 25% complete.

Bids have been accepted on the reactor assembly and on the moderator storage tank. The total price is $23,535. Bids are due back January 30 on the thimble coolant pump and the reactor pumps. Bids are being requested on the instrumentation package, the thimble tube blower, and the in-cell valves.

The vendor on the fuel transfer lock has advised the scheduled shipping date of February 3, 1961, will be extended by about ten days. Expediting has been encouraged to take all possible steps to minimize the delay.

Fuel Element Rupture Test Facility (Project CAH-867). The GE portion of the detail design is essentially complete except for minor changes. It is planned to route drawings and specifications for approval during the first week of February. Detail drawings and specifications have been received from Cornell, Howland, Hayes and Merryfield for the water plant effluent holdup tank.

A schedule for construction of the underground annex was received from the contractor, George A. Grant. The schedule indicates completion of the Rupture Facility part of the work on April 24, 1961. Scheduled progress to date is 60%; progress is on schedule. It is planned to provide the bid package data to the Commission for the installation of equipment in the annex building by February 15.

Orders were placed with Illinois Water Treatment Company for the makeup ion exchange system and for the vacuum deaerator. Total cost for these items was $31,024 as against $40,000 allocated in the project proposal. The specification for control valves was completed and is being submitted for bid. The specification for the instrumentation package is completed; submittal for bid awaits the completion of associated drawings. The specification for the electrical switch-gear is being prepared. Approval drawings were submitted and approved for the two Aldrich pump units (RLP 1A, 1B) and for the Pfaudler heat exchanger (RLHX-2).

Tracings of the in-reactor components of Test Section "A" are being circulated for approval. All purchase orders have been placed for materials and nozzle material has been received. Fabrication will start as soon as approved prints are available.

The rupture loop in-reactor mockup for critical tests was completed and delivered to the PRTR.

Design and Component Testing

PR-10 - Primary Loop Mockup. The spare primary pump operated an additional 418 hours during the month for a total of 3949 hours. Lower operating efficiency was due to malfunction of the automatic temperature controller. The pump has operated consistently with less than one mil vibration since the addition of eight additional springs for a total of 16 for a spring force of about 2000 pounds to provide more stable thrust conditions.

The prototype pump with the self-adjusting seal assembly has operated 733 hours during the month for a total of 5336 hours. The present leak rate is 0.3 to 0.5 GPH.

The seal test stand has operated 405 hours and 54 starts with two seal assemblies identical to those on the primary pumps. The stand is operating 7-1/2 hours/day at 1800 RPM and 1100 psig.

The Aldrich injection pump test run using R/M Vee-Flex packing with finger springs was terminated after 3665 hours when additional gland tightening could no longer reduce the leakage to a drip. Examination revealed badly broken springs and cast doubt as to their value. A new run with the Vee-Flex rings and no springs has now been in progress for 351 hours.

PR-40 - Shim Control. The three assemblies which had different rod material for use in critical tests were rewired with the new silicone varnish im-

Testing will continue to determine the best roll-in torque, easiest collapsing method, and to improve the weld cutting tool.

A purchase requisition has been written for a borescope for shroud tube inspection.

Flexure Loop. The test of the three-clamp Grayloc transition union, stainless steel to Zircaloy, for use at the ETR Loop, was resumed on January 24, 1961, following delivery of properly tested and inspected studs and nuts. The union was made up with 100 ft-lbs torque on each stud instead of the originally specified 140 ft-lbs. The joint was hydrostatically tested at 3000 psi without leaking.

The union had previously operated 200 hours at 1200 psi and 24 cycles in temperature, 200 to 525 F, and 11 hours at 2000 psi and one cycle at 200 to 600 F.

Fuel Element Examination Facility Duct. The two zipper ducts were shortened. The ducts and transition pieces are 80% complete. Delivery of the frame from Barnes and Company is expected in February 1961.

Design Analysis

PRTR Critical Tests. The second group of critical experiments was initiated with an approach-to-critical experiment for a Pu-Al fueled core. Preliminary analysis of this data indicates criticality can be achieved with 12 Pu-Al elements loaded into the center tubes and the moderator at a level of 101 inches. An analytic fit to the data also indicates that the critical moderator level would be above 30 inches with 36 Pu-Al columns.

A full core loading of 63 UO_2 and 22 Pu-Al fuel elements was utilized for half-level critical experiments. With a critical moderator level of 55.6 inches, an average level coefficient of 5.7 mk/in was measured, in good agreement with calculation. The loading for the remainder of the critical tests was established with 55 UO_2 elements and 30 Pu-Al elements, which were located nearer the edge of the core. A critical moderator level of 61.5 inches and an average level coefficient of 5.9 mk/in were measured for this loading. Although this level coefficient does not agree as well with calculations as do previous measurements, the experimental error is believed large enough to account for the difference.

More complete measurements on the reactivity worth of the shim system have been carried out. Preliminary results indicate the maximum strength of the shim system is higher than previously estimated on the basis of single rod measurements. With one shim assembly removed from the core (for installation of a level measuring probe), a measured strength of 127 and 113 mk was obtained for the overlapped and fully extended configurations, respectively. Installation of the 18th shim assembly will raise these values about six percent. These values lead to a maximum single

rod strength of about 70 cents. Additional measurements of the contribution to the total negative coolant void coefficient from concentric fuel regions were completed. Voiding the central 13 UO_2 tubes was found to result in a slight positive effect of about 0.04 mk/tube. Voiding 12 plutonium tubes resulted in a strong negative effect of 0.5 mk/tube. Finally, removal of coolant from the 24 UO_2 tubes at the edge of the core resulted in a negative value of 0.1 mk/tube. The total reactor coolant void effect estimated from these measurements is about -15 mk, in good agreement with the earlier result.

Reactor power was held constant during one of the critical tests long enough for RMO personnel to obtain neutron dose rates through the top and bottom primary shields (with rotating shield removed). The following dose rates were obtained, using a double-moderator dosimeter:

	Fast Neutrons		Thermal Neutrons	Reactor Power,
Location	Mrem/hr	Avg. Energy	Mrem/hr	Watts
Top shield	6.0	~0.6 mev	0.1	1000
Bottom shield	3.0	~0.9 mev	0.2	400

These initial measurements indicate that reactor hall dose rates during full power operation may exceed design levels slightly.

PRTR Rupture Loop. Dose rate calculations were made for the case of removal of an irradiated fuel element from the Rupture Test Facility. During this operation the minimum water cover of 7-1/2 feet occurs in the PRTR fuel transfer basin. Dose rates of about 50 mr/hr could occur at this point.

PRP Critical Facility Analyses. Analog computer studies were conducted to determine the capacity of the PRP Critical Facility safety system for safely terminating nuclear excursions due to various step and ramp reactivity inputs. These studies showed that, with the reactor critical at the time the reactivity input began, the rod safety system would prevent fuel element melting for step reactivity increases up to 25 mk and for ramp additions up to about 32 mk per second. No mechanism for adding reactivity at rates approaching these has been postulated.

The rough draft issue of the PRP Critical Facility Hazards Report was completed.

Dose rate calculations were made for the Critical Facility hazards study. Failure of the Critical Facility water lock would lower the storage basin water level five feet. Under these conditions a maximum dose rate of about 100 mr/hr could occur over the fuel element storage area containing 128 PRTR fuel elements.

The three-group diffusion theory code, FLUX-WEIGHT, has been compiled in final form and debugged. It is now being utilized for criticality and important weighting calculations for the PRCF core design.

Stress Analysis of the PRTR Primary Loop. Stress analyses of the PRTR pressurizer and steam generator nozzle regions of the PRTR primary coolant system were analyzed and compared to the safety requirements of the ASA Power Piping Code, the ASME Unfired Pressure Vessel Code, and the Tentative Design Basis Code for Nuclear Vessels used by the Bureau of Ships. The pressurizer inlet nozzle, which contains a bimetallic weld (clad carbon steel to stainless steel) was stressed excessively under certain operating conditions. Stress analysis of a proposed nozzle modification resulted in added flexibility on the nozzle side of the bimetallic weld and reduced resultant stresses to a level below the allowable limits defined in the ASME Unfired Pressure Vessel and the Nuclear Vessel Codes. Modification of the nozzle has started.

PRTR Operations

Reactor Testing and Activation. The second phase of the PRTR Critical Tests began on December 27, 1960, and was completed at month-end. Approximately 265 separate reactivity measurements, including 90 measurements of rising periods, were made for the programmed changes in the reactor core. Tests performed were:

C.T. No.	Title	Status
12A	Approach-to-Critical Exp. for Uniform Pu-Al Loading (8" lattice)	Completed
13A, B	Three-Zone Approach-to-Critical Exp's.	"
14A, B	" " Critical Experiments	"
14C	" " Level Sensitivity and Shim Calibration Experiment	"
10B, Pt. 1	Moderator Void Coefficient (overflow)	"
15	Poison Calibration of Level and Shim	"
16	Reflector Savings	"
27	Spike Enrichment Addition	"
34	Gas Loop and Rupture Loop Test Sections	"
28	Calibration of Substitute Shim Materials	To be done
30	Black Rod Replacement	" " "
10B, Pt. 2	Moderator Void Coefficient (top drain lines)	" " "
10C	Scram Transient	" " "
21	Cell Flux	*

*The Cell Flux experiment will be done if it is possible to remove the calandria access plugs. To date, it has been impossible to remove these one-inch plugs using up to 300 ft-lbs of torque.

The temperature coefficient Critical Tests (CT's 31, 32 and 33) have been rescheduled and will be performed during the period just preceding Power Tests. These Critical Tests are currently scheduled to begin about February 22. Construction completion and design testing will set the exact date. Critical Test 21, Cell Flux, will also be accomplished at that time.

Performance of Design Tests continued. The top and bottom shield coolant system was heated to 150 F under Design Test 13. Apparent expansion of the water in the system during the heat-up period was found to be approximately forty gallons rather than the expected ten gallons. Efforts to remove all air trapped in the top and bottom shields are being continued.

Excessive vibration and shaft whip were observed in one of the top and bottom shield pumps. The pump was dis-assembled, and a small grinding wheel was found lodged in the impeller. The pump was re-assembled and testing is continuing.

Several sections of Design Test 7 (Moderator System - Cold) were completed. Design Test 42 (Moderator System Volume Determination - D_2O) was also completed. Detailed preparations for the following four Design Tests are under way:

Rupture Detection System
Secondary Coolant Activity Monitoring System
Process Area Exhaust Filter
Process Cell Waste Collection System.

Design Test 55 (Moderator and Gasometer Level Stability) was written and approved during the month.

The process water reservoir supply valve system was replaced with a new system incorporating a pneumatic level transmitter and diaphragm-operated valve. Continuous automatic control of reservoir level was achieved using the new system.

Moderator pump problems threatened to interfere with Critical Tests several times during the month. A check valve failure prevented operation of Pump #2 and motor bearings failed on Pumps #1 and #3. All repairs were accomplished during scheduled "down" times without interrupting Critical Tests.

Failure of both seals on the main personnel air lock occurred on two occasions during January. It was necessary to stop Critical Test work during the day shifts until the seals were repaired since it was not possible to use the main air lock and maintain the integrity of containment. During the night shifts Operations personnel used the emergency air lock for access to the containment vessel.

Progress of Critical Test work was slowed on a number of occasions when D_2O and helium leaks were encountered. Filling of the process tubes with D_2O was delayed due to packing gland leakage from tube isolation valves. Approximately 200 pounds of D_2O were lost before valve leakage was stopped. Efforts to reduce helium leakage continued. After correction of major leaks, moderator gas balance system leakage was reduced to three scfm. Further improvement was realized as smaller leaks were found and corrected.

An unexpected operating incident occurred on January 24. Critical Tests were being performed with all containment valves closed. The containment circuit had been de-energized for relocation of some conduit. Containment vessel pressure gradually increased during the time the containment valves were closed. When the conduit repair was complete, the containment circuit was reset. At this time, vessel pressure was vented through the re-opened ventilation containment valves. This caused a sudden decrease in gasometer pressure which in turn resulted in a sudden increase in moderator level. At this time moderator level was two inches below estimated critcial for a multiplication experiment. The technician at the console, although not realizing the cause, recognized the abnormal condition immediately. He manually tripped open a control valve to lower the liquid level and terminate the incident.

Shim rods, since rewiring and installation of new motors, have performed satisfactorily. Position read-out accuracy is still less than desired, but a revised circuit currently under test is expected to solve this problem.

Long term testing of the river pumps was completed satisfactorily in early January. During this test period Pump #1 operated for fifty days and Pump #2 ran forty-six days.

PRTRO personnel prepared a punch list and are providing assistance in the acceptance test follow-up of the helium system. The fuel handler punch list was reviewed, and a list of exceptions was provided to design and construction personnel.

The #1 primary pump was overhauled to repair a leaking seal. The seal leakage was caused by a minor fault which may have occurred during assembly of the pump. The motor was re-assembled using an insulated end ball designed to eliminate induced currents in the bearing surfaces and thus avoid pitting of the bearing surfaces caused by galvanic action.

Plans and Procedures. Preparation, review and approval of the Operating Standards and Procedures continued through January. At month-end, eighty of the ninety-one procedures and seventy-six of the eighty-seven standards had been approved.

Test descriptions of two Power Tests were approved by the PRTR Startup Council. Detailed test procedures were prepared for two tests. Arrangements were made to install vibration monitoring probes for Power Test 8. Linear differential transformers were ordered for measuring fluid volume change as a function of temperature. Noise monitoring equipment will be installed by month-end as required by another section of Power Test 8. Equipment procurement for other Power Tests is under way.

Approximately 200 pages of revisions and additions to the Electrical Manual were issued during the month. These covered work on the Maintenance and Mockup contracts, numerous Phase III-A construction items, and the addition of the gas loop equipment to the PRTR facility.

The gas loop components, design data and construction reports were reviewed with the third party inspector in preparation for coding the entire loop.

Portions of the Gas Loop Operating Procedures, Valve Manual, graphics training aids, and a model of the gas loop components were prepared during January. Arrangements for ordering spare parts for the loop were made with Plant Engineering personnel. An alternate sample handling cask design was presented to DDO for consideration. Construction liaison continued.

The specifications for all rupture loop components were reviewed and comments forwarded to design personnel.

2. PLUTONIUM CERAMICS RESEARCH

Plutonium Dioxide-Uranium Dioxide

Investigations have continued on the crystallographic stability of PuO_2 from 300 C calcined oxalate. The majority of sintering data has been on PuO_2 obtained by a 300 C calcination. In an experiment to delineate interaction with the furnace boat, PuO_2 pellets were heated to 1500 C in dry hydrogen on Ta, oxidized Ta, Al_2O_3, Mo, and W boats. Both surfaces of each pellet were examined by mounting the pellet in a special jig adapted to the goniometer of a GE XRD-5. Copper radiation ($K\alpha_1$ = 1.54051 A) was used. The pellets which had been resting on Ta showed extreme amounts of alpha Pu_2O_3. In one case the x-ray intensities of the Pu_2O_3(222) versus the PuO_2(111) showed about 70% alpha Pu_2O_3. The pellet resting on Al_2O_3 showed only large quantities of Pu-Al_2O_3, and the pieces on Mo and W also gave no indication of alpha Pu_2O_3. On some of these samples reflections were seen at 2θ angles of 27° and 31°, which correspond closely to the beta Pu_2O_3(100) and (101); however, no other lines were observed. Based on the La_2O_3 isomorphism, several other strong lines would be expected if beta Pu_2O_3 were present. In addition, the ratio of the intensities of these lines varied considerably, indicating that if this is beta Pu_2O_3, the structure might possess a strongly preferred orientation. To determine whether these lines were merely the result of deposition of vapor from the furnace refractory, a UO_2 pellet was sintered, but x-ray examination showed no extraneous lines.

On oxidation of these pellets at 800 C in air, weight gains showed the O/Pu ratio to be between 1.86 and 1.90, which corresponds to roughly 25% Pu_2O_3, and is most surprising in view of the Pu_2O_3 quantities seen on the diffraction patterns. This would indicate that a highly reduced surface skin is present while the bulk of the pellet is not nearly so oxygen-deficient. This is supported by an experiment in helium, in which 20% alpha Pu_2O_3 was seen by x-ray diffraction, while oxidation yielded a meager 1.97 for the O/Pu ratio.

The weight loss on the above pellets was about 4.25%, approximately two percent greater than can be accounted for by weight gain and by liberation of adsorbed gases. This indicates a loss of plutonium and since reduction of PuO_2 is known to begin at about 1100 C in hydrogen, it is thus likely that Pu_2O_3 or a PuO_{2-x} species has a considerable vapor pressure.

It has been found previously that the reduced skin could be easily removed by grinding as little as 0.002 inch from the surface; however, calculation of the depth of oxygen depletion was not consistent with the surface x-ray data. PuO_2 powder which had been sintered at 1500 C in hydrogen was heated at 50 C and 100 C increments in air and complete oxidation had occurred by 200 C. This indicates that rather than removing Pu_2O_3 from the surface during grinding treatments, it was instead oxidized by the heat of working.

An illustration of the ease with which a PuO_{2-x} surface may be oxidized, or else of the volatility of Pu_2O_3 was seen during heating on vacuum. A pellet whose surface showed about 40% alpha Pu_2O_3 and gave a PuO_2 lattice parameter of 5.400 A was heated to 1100 C in a vacuum of 1×10^{-4} mm Hg and furnace quenched. On examination, only a sharp PuO_2 phase was seen, and its lattice parameter was the usual 5.39 A. It had been thought that single phase PuO_2 had been retained on quenching; however, oxidation gave an O/Pu of 1.85.

Attempts have been made to correlate the lattice parameters of PuO_2 and alpha Pu_2O_3 with O/Pu ratio. For the case of PuO_2, little success has been achieved due to the small unit cell expansion of the oxygen-deficient structure. The largest PuO_2 lattice parameter observed has been 5.401 A, indicating the fluorite structure does not exist with a large oxygen deficiency. A correlation between a_o and O/Pu is impossible then because the lattice parameter tolerances in some cases are $\pm$ 0.005 A.

Alpha Pu_2O_3 possesses the Type "C" rare earth structure which is essentially a stacking of eight fluorite cells but containing only 75% of the theoretical number of oxygen atoms. This is a defect structure and will accommodate more than the 48 oxygen atoms obtained from stacking eight PuO_2 cubes. As excess oxygen is introduced, that is, as $Pu_2O_{3+x} \longrightarrow PuO_2$, one would expect the cell side of the BCC Pu_2O_3 phase to decrease due to the insertion of excess electro-megativity. Conversely, as Pu_2O_3 apprcaches the ideal Type "C" rare earth structure, the increased anion loss should result in a unit cell expansion. In our experiments large amounts of Pu_2O_3 were seen only as a surface phase and were not representative of the O/Pu ratio of the sample bulk, hence one cannot plot Pu_2O_3 "a_o" versus O/Pu. It would be desirable to have a true surface O/Pu value, but as a substitute one may use the relative Pu_2O_3 quantity seen on diffraction patterns. When "a_o" is plotted against percent Pu_2O_3 on the sample surface, the inverse of the slope hypothesized above is obtained. The only plausible explanation for this lies in the cation sizes. Since Pu^{+3} has a larger ionic radius than Pu^{+4}, it would seem that in the Pu_2O_3 structure, the increased cation diameter would tend to "fill in" or at least decrease in size the vacancies that are formed by stacking the fluorite cubes and removing sixteen oxygen atoms. Any oxygen which is now added would fit with difficulty into the lattice and would cause an overall volume expansion. Thus, the Pu_2O_3 "a_o" would increase as O/Pu $\longrightarrow$ 2.0. From this it is speculated that the PuO_2 arrangement is a fairly stable one while the Type "C" Pu_2O_3 is the major defect structure and accounts for the increased oxygen loss as O/Pu ratios diminish. Extrapolating this plot to 100% Pu_2O_3 gives a lattice parameter of 10.971 A; however, it is doubtful that Pu_2O_3 exists at the ideal O/Pu ratio of 1.50.

The existence of an oxygen rich PuO_2 structure has been found in a specimen of PuO_2 powder heated to 1000 C in oxygen. During heating the sample actually lost weight due to the liberation of surface adsorbed gases. A back reflection x-ray pattern was obtained using a silver internal standard and Seeman-Bohlin focusing on the $PuO_2(444)$ plane. The resultant lattice parameter was 5.3852 ± 0.0008 A compared to the usual 5.3960 A. Since the ionic radii of Pu^{+4} and U^{+4} are 0.86 A and 0.89 A, respectively, the effect of excess oxygen on the contraction of an MO_2 type (fluorite) structure should be nearly the same. Applying the slope of the a_o versus O/U plot found by Hering and Perio to the case of PuO_2, the composition $PuO_{2.091}$ is obtained.

Lattice thermal expansion measurements on low temperature calcined PuO_2 were abandoned because of excessive crystallite size line broadening. This resulted in weaker x-ray diffraction line intensity, as well as making location of the center of each line less precise. The measurements on PuO_2 will be continued with a well-sintered sample of PuO_2.

Plutonium Carbides. A series of experiments during the past month on arc-melted PuC-UC alloys has indicated that increased additions of UC tend to suppress the quantity of Pu_2C_3 formed upon passing the PuC peritectic temperature of 1650 C. Complete stabilization of the FCC PuC-UC structure occurs with slightly greater than 25 w/o UC. A striking illustration of the PuC peritectic reaction was seen in a sample quenched from 1800 C in vacuum. The surface of the PuC button was deeply pitted and had reacted with the crucible while three PuC-UC alloys in the same run were unchanged in appearance. The PuC and Pu_2C_3 decompositions were observed at 1650 and 2079 C, respectively, which is in excellent agreement with LASL data.

A series of nine PuC alloys containing from 40 to 65 a/o C has been prepared by arc-melting metallic plutonium + carbon pellets. These buttons are being ground with a diamond wheel under CCl_4 to yield samples for the determination of the room temperature composition limits of the defect PuC phase. A Siemens back reflection integrating camera and a platinum internal standard will be used for analyzing Bragg reflections at $2\theta > 140^\circ$.

Preliminary values of the lattice thermal expansion of PuC and Pu_2C_3 have been obtained up to 780 C. The expansion coefficient of PuC is 10.8 x 10^{-6}/C and of Pu_2C_3 is 14.8 x 10^{-6}/C. The samples were contained in 0.5 mm quartz capillaries mounted in the high temperature x-ray diffraction camera. At a higher temperature the capillary fractured, requiring decontamination of the interior of the vacuum chamber. The film cassette, outside the vacuum chamber does not become contaminated.

Plutonium Silicides

A plutonium silicide has been prepared by two means. The first consisted of mechanically mixing the reactants according to the following equation and heating in a vacuum resistance furnace for one hour at 1400 C:

$$PuO_2 + 2\ SiC \longrightarrow PuSi_2 + 2\ CO.$$

The second method was by arc-melting a stoichiometric mixture of alpha plutonium and silicon metal under a static blanket of argon gas. X-ray diffraction data were substantially in agreement with those reported by Runnals and Boucher on the ASTM diffraction data card for beta plutonium disilicide. The products had a metallic gold luster, were quite brittle, and exhibited pyrophoricity.

Plutonium Oxide-Zirconium Oxide System. Specimens of the following compositions have been quenched in water from approximately 900 C: PuO_2-62, 64, 80, 90, and 97 w/o ZrO_2. Specimen form was generally that of a right cylinder 1/4 inch long and 1/2 inch in diameter. Data concerning high temperature equilibria were not conclusively determined due to the quenching rate and/or the quench temperature being too low. Specimen integrity was affected very little by the thermal shock on quenching. A few hairline cracks were observed, but there was no chipping or disintegration of the pieces.

Plutonium Oxide-Magnesium Oxide System. Investigation of the solid phase relationships occurring in the system PuO_2-MgO have recently been initiated. Nine different compositions at ten percent intervals between the limits of the pure components were pressed into pellet form and soaked for twenty hours at 1550 C in helium. The sintered densities decreased uniformly with composition extending from 10.65 gm/cc (92.9% TD) for pure PuO_2 to 3.18 gm/cc (88.9% TD) for pure MgO. These pellets were mounted in a cold setting resin and ground flat for x-ray diffractometer examination. The resulting scans showed for all compositions, only the pure MgO and PuO_2 structures with no evidence of intermediate phases. The lattice parameters of MgO and PuO_2, as determined from an average of the a_o from the three highest reflections, were for each composition near the accepted values of 4.213 and 5.396 A, respectively. This indicates no solid solubility between the two phases. It is presently planned, however, to look more carefully for signs of solubility at the terminal compositions.

4. UO_2 FUELS RESEARCH

Vibrational Compaction of UO_2. Microhardness surveys made on Zircaloy-2 tubing which was deliberately failed during vibrational compaction revealed no hardness increase in the fracture zone, which was near the weld. However, the extreme conditions, which brought about the failure did cause the interior surface near the fracture to become covered with a black (presumably oxide) layer. If appreciable oxygen or nitrogen diffusion into the tube wall had taken place, the metal would have become harder and more brittle, and thus more notch sensitive and more susceptible to fatigue failure. The hardness had not increased, indicating that little, if any, oxygen or nitrogen contamination actually occurred. Apparently, the fuel rod temperatures and times at temperature encountered during vibrational compaction are not sufficient to result in appreicable atmospheric contamination of the cladding, even under the most extreme vibration conditions.

Thermal Conductivity of UO_2. Final measurements of thermal conductivity were made at BMI on irradiated (3.48×10^{19} nvt) and non-irradiated (die-pressed) UO_2 specimens. The source of discrepancies in previous data from the irradiated specimen was discovered to be a faulty thermocouple. The final curve of conductivity versus temperature lies below that previously reported and shows a reduction in thermal conductivity with increasing irradiation at all temperatures up to 600 C.

Thermal conductivity measurements in the non-irradiated UO_2 were extended to 1400 C. Data define a curve of continuously decreasing values with increasing temperature. Visible cracking occurred at about 1200 C; repeated measurements made thereafter yielded values about 10% lower at all temperatures.

Work was begun on thermal and electrical conductivity measurements on UO_2 irradiated to 1.52×10^{20} nvt. Non-irradiated UO_2 being prepared for measurement of thermal conductivity includes a large single crystal and specimens prepared by vibratory compaction and by isostatic pressing.

High Energy Impact Forming of UO_2. High energy impact forming is being employed to densify depleted UO_2 for vibratory compaction in a prototype, nested tubular fuel element to be irradiated in the ETR. The material is compacted in a conventional impact-forming die in stainless steel cans which hold approximately one pound of UO_2. The cans are heated to 1100 C before compaction. The bulk density obtained with this particular starting material is 97.5%.

High Temperature Microscopy Studies. Facilities suitable for storing, preparing, and examining small irradiated specimens of UO_2 for high temperature studies in the 325 Building have been arranged. These consist of a small cave shielded by six inches of lead and equipped with a pair of Argonne model 7 master-slave manipulators. Ten-gram lots of irradiated UO_2 having eight different exposures were transferred to the cave and preparation of microscopy samples was begun.

Electron Microscopy. Examination of single crystal (fused) UO_2 continued. Specimens being studied involve polished and etched surfaces, cleavage surfaces (by replication techniques) and "chips" and solid surfaces (by direct transmission and reflection methods).

It was found that regularly shaped impressions with a maximum dimension of as little as 10 microns can be made with a Tukon microhardness tester and used as "standard impressions" for observations through the electron microscope. These will be of use in relocating specific areas of pre-characterized surfaces and for providing directional references.

Information Exchange. Hanford studies on ceramic fuels were summarized at the eleventh meeting of the High Temperature Fuels Committee (held at General Atomic, January 10-12, 1960). Preliminary arrangements were made to obtain additional specimens of high burnup (> 100,000 MWD/T) UO_2 from Bettis and KAPL for examination in the CFDO high temperature and electron microscopes.

US/UK Research Newsletter No. 10 on Uranium Oxides was compiled, duplicated, and distributed to the information exchange participants in the U.S. and the U.K. The newsletter has grown to 54 pages in which are described the ceramic fuel basic studies and technology reported from sites throughout the United States.

Editing and obtaining participant approvals of the record of the second US/UK UO_2 Information Exchange Meeting (Hanford, Oct. 25-28, 1960) are approximately half completed. We are now awaiting approvals from Harwell.

4. BASIC SWELLING STUDIES

Irradiation Program

Capsule No. 7 containing three hollow, split uranium cylinders is awaiting irradiation. This capsule will be the fourth of the current series to be irradiated. Capsules No. 4 and 5 are in Radiometallurgy for post-irradiation examination while Capsule No. 6 is in the reactor discharge basin to permit sufficient radioactive decay prior to shipment for disassembly and specimen examination. Capsule No. 8 is completely assembled and currently awaits bench testing under simulated reactor conditions.

Pore Size and Distribution

Optical and electron microscopy are being used as a direct means of determining the size and distribution of pores in irradiated uranium. Replicas of uranium with burnups of 0.29 a/o and 0.41 a/o annealed at various times and temperatures have been rephotographed, and the pores in "random" micrographs are being remeasured with a Zeiss Particle Analyzer. This repetition of work previously performed is necessary since previous measurements were insufficient in number to give a good estimate of the pore frequency distribution which existed in the entire specimen, and previous measurements and subsequent analysis of pores did not provide adequate resolution among small pores.

Fission Product Mobility

A knowledge of the mobility of rare gas fission products in uranium is important to the understanding of the basic mechanisms underlying the swelling phenomenon. Uranium specimens are being examined that have had inert gas introduced into the surface by "glow" discharge and U-U diffusion couples are being studied under conditions such that one part of the couple contains a large concentration of fission products while the other part contains little or no fission products.

Restrained Irradiations

In-reactor swelling experiments of Zircaloy-2 clad uranium fuel rods with selected uranium temperatures, cladding thicknesses, and exposure are being conducted employing NaK-filled, temperature monitored capsules. Five swelling capsules, GEH 14-94, 14-95, 14-99, 14-104, and 14-105, are presently being irradiated in the MTR to various goal exposures. Exposures

and average center uranium temperatures for the fuel rods in these capsules through MTR Cycle 149 are, respectively, 0.07, 0.17, 0.31, 0.59, 0.52 a/o and 575, 500, 290, 600 and 335 C. Five capsules have now been discharged from these MTR tests and will be examined in Radiometallurgy during the succeeding months. Dimensional measurements have been made on three 1.6 percent enriched uranium rods coextrusion clad with Zircaloy-2 and irradiated in capsules at Hanford to 0.14 a/o burnup. Volume increases are in the range from one to two percent at uranium temperatures from 425 to 490 C. Calculated R values are between seven and fourteen. It is hoped that density measurements will give more accurate R values. Seven other capsules from this same series of tests are now being opened at Radiometallurgy. Measurements of volume changes will also be made on these fuel rods.

5. IN-REACTOR MEASUREMENTS OF MECHANICAL PROPERTIES

In-Reactor Creep Measurements

Operational performance of the second generation creep capsule in the reactor has shown a critical weakness in the thermocouple assemblies used in the capsule. The first indication of weakness in the thermocouples occurred when the reactor shut down after the capsule had been operating. At that time the temperature drop caused two of the six thermocouples mounted on the specimen to fail. However, the problem was not considered serious since duplicate thermocouples had been provided on the specimen and the temperature could still be monitored. During the next reactor cycle the temperature was lowered 50 C, and two more thermocouples failed. Analysis of the thermocouple failures indicate that the failures occur in the insulators through the pull rods. One of the remaining capsules is being thermally cycled in the laboratory to confirm the analysis before the capsule is modified.

Capsule and Instrument Development

Bids have been received for the construction of a series of third generation capsules. All vendors stated compliance with the specification document, HW-67183, "Specifications for In-Reactor Creep Capsule." Selection of vendors was based on technical competence and price. The specifications for the third series of capsules call for extensive simplification in the construction of the capsule while retaining the reliability and accuracy of proven methods and techniques used in the first two capsules.

Pre-Irradiation Material Characterization

Measurement of the activation energy for creep of the Zircaloy-2 scheduled for in-reactor testing has continued. Creep tests giving data for the calculation of activation energies are being conducted on annealed Zircaloy-2 at stresses of 15,000 psi and 20,000 psi, and on 20% cold worked material at a stress of 35,000 psi. The activation energies are calculated from the creep rates immediately before and immediately after an abrupt temperature change. Annealed Zircaloy-2 at 15,000 psi has shown

little change in creep rate with abrupt temperature increases of 15 C in the temperature range 200 to 272 C, indicating an activation energy of zero cal/g-mole. The activation energy for the 20% cold worked material measured at 209 C was also found to be zero. Sufficient data for the calculation of activation energy of annealed Zircaloy-2 at 20,000 psi are not yet available. The zero value of activation does not require the total creep strain or minimum creep rate attained in creep testing Zircaloy-2 to be independent of temperature. Creep is a complex deformation process at temperatures below the dislocation climb region and effects other than thermal activation play important roles. Creep data from other sites indicate the total creep strain and minimum creep rates are considerably less temperature dependent at temperatures below 300 C than at temperatures higher than 300 C.

6. GAS-GRAPHITE STUDIES

EGCR Irradiation

The H-3-2 experiment is operating satisfactorily in the second cycle of irradiation in the GETR. The full cycle, longitudinal flux distribution ($E > 1$ mev) in the GETR core near the experiment has been determined. This was based on the cadmium covered sections of the nickel wire stretched vertically along the F-3 position and irradiation during Cycle 15. An effective thermal absorption cross section for Co-58 of 3750 barns was calculated from the same wire. This is the mean value required to correlate the results from the bare nickel wire with those from the cadmium covered segments.

EGCR Combustion Hazard Evaluation

Tests were conducted recently in the EGCR burning rig with a non-reactive core installed to simulate silicon carbide coated fuel sleeves. Data indicated with an air flow of four lbs/hr self-sustained combustion did not occur at graphite temperatures less than 600 C. These data and data from previous experiments are presently being used in a computer analysis of EGCR hazards by ORNL and Allis Chalmers.

Upon completion of experiments with the non-reactive core, the rig was disassembled and modified to accommodate testing with a mockup of an EGCR lattice unit including dummy fuel elements, silicon carbide coated fuel sleeves and actual EGCR graphite for the moderator. Full size coated sleeves were received from ORNL and inspected before loading into the burning rig. Borescope photographs of the inside of the tubes were made. These will be compared to photographs of the same spots after the burning tests. Modifications have been made to the burning rig to program the calculated reactor heat flux decay function into the heater power.

Effect of Temperature on Radiation Induced Graphite Contractions

A combination of the results from the GETR H-1 and H-3 experiments gives a reasonably complete description of the effect of irradiation temperature on the contraction rate of nuclear graphites. In general, the transverse

contraction rate goes through a broad minimum between the temperatures of 650 and 950 C with the least contraction occurring at approximately 800 C. Needle-coke and CSF graphites show the same effect but differ in magnitude. The contraction of needle-coke graphites (similar to EGCR or NPR specification material) is approximately 0.6 of the CSF ($\perp$) rate at all temperatures. The results are shown in the following table.

CONTRACTION OF NUCLEAR GRAPHITES AT HIGH TEMPERATURE

Irradiation Temperature, C	Rate (arbitrary units) Needle Coke Graphite ($\perp$)	CSF ($\perp$)	Both Graphites ($\parallel$)
450	0.055	0.085	0.155
500	0.040	0.065	0.124
600	0.023	0.035	0.065
700	0.015	0.022	0.050
800	0.012	0.020	0.060
900	0.014	0.025	--
1000	0.021	0.035	--
1100	0.038	0.060	--
1200	0.070	0.100	--

The "arbitrary" units above represent contraction in terms of percent per 10^{21} nvt ($E > 0.18$ mev) with the dose estimated from computer calculations. The existing foil activation measurements indicate that the neutron dose may be less than calculated; perhaps by a factor of two. Based on theoretical calculations and using available spectra data, 10^{21} nvt ($E > 0.18$ mev) in the GETR E-7 position is equivalent to 7500 MWD/AT in the EGCR. Thus, an "arbitrary unit" of 0.01 is believed to represent a contraction rate between 0.0013 and 0.0026% per 1000 MWD/AT.

Oxidation Inhibitor Studies

An investigation is in progress to test the effectiveness of chlorine as an oxidation inhibitor in the presence of ionizing radiation. Tests in the gamma irradiation facility demonstrate the ability of chlorine to reduce oxidation rates to about the same extent as in the absence of radiation. Experiments conducted in ozone indicate the rate law developed for thermal oxidation inhibition applies in the case of oxidant species activated by radiation.

Oxidation Studies in the Cobalt-60 Irradiation Facility

A test was started in two identical glass loops in the cobalt-60 irradiation facility to determine whether gamma radiation promotes a reaction between carbon and nitrogen at 670 C. Samples are subjected to the same temperature and gas flow rate, the only difference being the gamma intensity which is 9×10^5 rad/hr in one loop and 250 rad/hr in the other. Because a graphite weight loss was observed during the first 72 hours due to oxygen impurities in the nitrogen, a gas purification system has been added.

The effect of gamma radiation on the reaction of small amounts of water vapor ($\sim$0.1 mm Hg) with graphite will be investigated using a recording balance in a third glass loop. This test has been delayed by difficulties with the temperature controller and saturable reactor.

Surface Complex Studies

Attempts to demonstrate the chemisorption of surface oxides on small graphite samples by measuring weight changes have been unsuccessful. All weight gains are observed to result from physical adsorption of the reactive gases employed, even under conditions where oxidation, which requires chemisorption, occurs. However, the sensitivity of the balance used in these experiments is such that an upper limit for chemisorption of 1.4×10^{17} sites/gm can be set for the reaction:

$$C_f \text{ (free sites)} + CO_2 \longrightarrow C(O)\text{(chemisorbed)} + CO.$$

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

An extension of the project completion date to September 30, 1961, was requested by Revision III to the project proposal. Based on the June 30 completion date, over-all construction is 55% complete versus 60% scheduled. The Head Mechanical work (auxiliaries and service piping, J. A. Jones Subcontract JAJ-73) is approximately 90% complete versus 95% scheduled. Installation of the ex-reactor section package is tentatively scheduled for the first week of February dependent on PRTR startup scheduling.

The date of delivery of the main blowers by Bristol-Siddeley, Ltd., remains indefinite. The contractual delivery date was about one year ago.

Component Testing. The gas loop in-reactor test section was run for about twenty hours. Maximum temperatures achieved were 1500 F heater temperature, 1300 F inner shroud temperature, and 700 F pressure tube temperature. These temperatures were achieved with no water around the calandria shroud tube or top and bottom shield tubes and with about 180 pounds per hour of helium in the cooling annulus. At lower temperatures, helium flow was kept as low as 80 pounds per hour compared with a design flow of 200 pounds per hour. At about 1500 F heater temperature during the last run, the heater shorted out and burned two of the conductors in two. The heater was removed from service and is being repaired.

Operation of the diaphragm compressor was stopped for installation of additional safety circuitry and addition of an on-off cycle timer.

7. GRAPHITE IRRADIATION DAMAGE STUDIES

Flux Dependence of Radiation Damage

Four capsules containing a total of 12 samples were charged in the MTR at the beginning of Cycle 151. This is a repetition of previous experiments to determine the flux dependence of low temperature radiation damage in graphite. A repetition is necessary since exposure determinations in previous experiments are now thought to be substantially in error.

National Carbon Company Research and Development Contract

The third lot of samples were discharged from a hot test hole after an exposure of 852 MWD/AT. Included in this irradiation were control samples of CSF and samples of TSX, NPR core graphite. The TSX samples are from Bar 152, and a statistical analysis of the x-ray data from this bar and from other bars of TSX has indicated that Bar 152 is less well graphitized than other TSX bars which were guaranteed for 3000 C heat treatment. Data for samples in this irradiation are found in the accompanying table.

Length Changes After 852 MWD/AT Exposure at About 550 C

Graphite		% L
TSX ⊥ (Bar 152)		+0.015
∥		+0.005
CSF ⊥		+0.016
∥		+0.014
Lampblack - 2" sample	Almost isotropic	-0.13
4" sample		-0.12
Hot worked ⊥ 4" sample		+0.001
∥ 2" sample		-0.012

8. SPECIFIC FUEL CYCLE ANALYSIS PROGRAM

Conceptual Design - Fuel Element Fabrication Plant

A meeting was held January 16, 1961, to discuss and resolve comments on the first draft of the process description and preliminary computations part of the study. Several pertinent comments were offered, among them that ordinary tolerances suffice for tubing for vibration-packed oxide elements, and that the complications attendant upon zirconium end plugs in contact with uranium oxide in the high flux zone of the reactor reduce or cancel the advantages of segmental charging obtainable with shorter than full core length elements. The process has therefore been revised to eliminate resizing and straightening of tubes, and machine sizes are

now based upon 10.06-foot tubes in numbers about half those previously calculated for five-foot tubes. Plant layouts based upon the new machine numbers and sizes are now being prepared.

9. SUPERCRITICAL PRESSURE WATER REACTOR STUDY

Pursuant to establishment of the ground rules by the Division of Reactor Development, Atomic Energy Commission, that the conceptual design of a Supercritical Pressure Water Reactor be an H_2O cooled, 300 MWe unit, studies have been undertaken to determine the type of moderator, turbine cycle, coolant operating conditions, and containment philosophy that will produce the most economical power generation.

Initial studies have issued in the selection of a thermal neutron spectrum because of the poor neutron economy in the epi-thermal region and spectrum degradation in the fast region resulting from the H_2O coolant. As a result, three types of moderators are presently under consideration: light water, heavy water, and graphite. While present evaluations are not sufficiently complete to permit a choice, the following factors are worthy of note:

1. The heavy water moderated reactor is attractive from the standpoint of reduced fuel cycle costs (possibly a quarter mill less than light water moderated reactors), but the cost of the heavy water may be as high as five million dollars. Other items being equal, a quarter mill fuel saving would make D_2O competitive at a price of about four million dollars.

2. The light water moderated reactor is attractive from a low moderator cost point of view, but pressure vessel diameter limitations (about six feet inside diameter), or difficult piping problems with small lattices and pressure tube type fuel elements, may severely limit its potential.

3. The graphite moderated reactor occupies a mid-position between heavy and light water with respect to cost (about one million dollars) and fuel cycle costs. The magnitude of graphite cooling and hot graphite-steam reaction problems are unknowns at present.

As far as turbine cycle considerations, it appears that each percent increase in thermal efficiency will permit one million dollars in direct construction expense (for a given kwhr cost) so that considerable optimization of the cycle is warranted. On this basis a double reheat, manifold preheat thermal cycle with high coolant temperatures appears desirable.

The question of where to enact containment on a direct cycle supercritical pressure reactor of large size presents problems. With two turbine generator units 125 feet long by 20 feet wide, one is prone to place them exterior to a more conventional containment vessel and place containment valves in the steam lines, or conversely, to use a pressure suppression type structure and place the turbines alongside the reactor and minimize

piping runs. Obtaining containment valves to close against supercritical pressures may pose a significant problem.

The information developed on the supercritical pressure reactor concept to date is of a very preliminary nature and caution should be applied to the tentative considerations presented here.

D. RADIATION EFFECTS ON METALS - 5000 PROGRAM

Radiation damage recovery is being studied for a number of metals, namely, copper, nickel, titanium, zirconium, iron, molybdenum, and type 347 stainless steel. A series of isochronal anneals are being performed on irradiated iron in order to determine the effects of varying impurity levels on the occurrence and magnitude of the various recovery stages. The studies are being concentrated on samples with exposures in the range $2.0\text{-}4.3 \times 10^{18}$ nvt. The samples were originally machined from three ingots: ingot 1 contained one ppm nitrogen and 60 ppm oxygen; ingot 2 contained one ppm nitrogen and 130 ppm oxygen; and ingot 3 contained 13 ppm nitrogen and 200 ppm oxygen. All specimens have shown similar recovery stages with slight variations in the temperatures at which maximum recovery rates occurred. As expected, the effect is more pronounced in the electrical resistance tempering curves than in the microhardness curves. The effect of exposure has also been studied. The data are still incomplete, but it appears that at exposures of approximately 1×10^{20} nvt, there is only one recovery stage; at 3 to 5×10^{18} nvt, there are three; at 1 to 2×10^{18} nvt, there are two stages; and at 1×10^{17} nvt, there is one stage with indications of a second.

Isothermal annealing at 550 C of zirconium exposed to 1.5×10^{20} nvt has disclosed the fact that the A_o parameter recovers rapidly while the C_o parameter increases rapidly, then decreases (after 10-15 minutes at temperature) and increases again to the fully recovered value after 20 minutes at temperature. The C/A ratio decreased 1.5% in the time interval of five to ten minutes, indicating a general shrinkage in the $[\bar{0}001]$ direction.

Tensile tests at elevated temperatures have been performed on irradiated molybdenum specimens. Several general observations have been made: (1) at temperatures below 500 C, immediate reloading after a pre-strain of 1% results in a decrease in the flow stress; (2) aging for two to four hours at the test temperature (300-500 C) causes a marked increase in the flow stress; (3) at temperatures from 300-500 C, initial yielding is immediately followed by an almost instantaneous drop-in-load of 20 to 35%. This load drop is accompanied by the production of an offset in the specimen along the plane of maximum shear (45°). The deformation band along this offset is seen to consist of extremely deformed grains with a heavy density of slip bands roughly parallel to the plane of the offset. At a distance of 1/4" from the deformation band, the grains are relatively undisturbed and the slip band density is several orders of magnitude less. Cross slip has been observed, indicating that at least two slip systems are operative. It is not known whether this behavior is due to an inhibition of some slip systems by radiation-induced defects or to a pronounced texture in the specimen. Pole figures will be obtained to determine the texture of this material.

E. CUSTOMER WORK

Radiometallurgy Service

No indication of a leak through either weld has been found in the I&E hole failure (1656-C) nor was there any evidence of spire cracking under the female cap. What appeared to be an inclusion was found in the spire wall and is most likely the cause of the failure (RM-412). The point of water entry in the I&E hole failure (4584-KW) was a small hole in the male weld connecting with a large void in the outside braze layer (RM-415). A third I&E hole failure (1471-KE) was sectioned through the rupture at the female end. The point of water entry has not yet been found. Ellipticity of approximately 50 mils was measured near the center of the element. Evidence of mud cracking was noted on the outside edge of the uranium core(RM-417).

Metallography Service

A stain etch has been developed for use on zirconium-beryllium alloys that produces high contrast between the alpha zirconium grains and the grains of $ZrBe_2$, which is the second phase present in the braze alloys currently under study. After initial preparation by either mechanical or chemical polishing, the sample is dipped for about one second in the stain etch which consists of 2% HF, 3% HNO_3 and 94% ethyl alcohol. A properly etched sample will produce a brown stain on the ZrB_2 phase and leave the alpha zirconium bright.

Sections of the cracked stainless steel KER Loop 4 tube were examined to determine the cause of failure. The initial failure occurred a few inches downstream from the water inlet from the heat exchanger and almost directly across from the feed makeup tube. Numerous cracks are evident on the inside surface of the tube progressing both longitudinally and circumferentially. Metallographic sections throughout the failure area show that these cracks propagate transgranularly through the wall of the tube and are of variable length. No cracks exist either seven inches downstream from the affected area or about sixteen inches upstream. Several possible modes of failure exist but the direct cause has not been determined.

Transmission electron diffraction patterns of specimens prepared from CSF, resin-impregnated graphite have been analyzed. Electron micrographs of two basic structures which are markedly different have been observed. The first type could be described as a bundle of longitudinally striated fibers or parallel plates when viewed from the side. Within the observed field at 40,000 magnification, a one micron area was selected for electron diffraction. An analysis of the diffraction pattern shows the 002 and 004 reflections to be highly preferred with two-fold symmetry. The 100 reflection is absent but the 101 is present and has a random intensity distribution. From this information it is known that the electron beam is normal to the c-axis and the thin film. Electron micrographs of the second type have irregularly shaped areas that give the appearance of grains with well defined boundaries. Selected area electron diffraction patterns from these regions result in the presence of a few oblique rings along with circular rings. On analysis, the 002 and 004 reflections are not present. The 100 reflection is present and shows a

slight preference for two-fold intensity distribution. The 101 forms a portion of an oblique ring. Previous work has shown the electron beam is striking the c-axis at an oblique angle. This angle is estimated to be between 43° and 63° for the specimen in our study.

One of the principal problems in studying the zirconium foils by transmission microscopy is sample preparation. This is particularly true for a study of cold work or irradiation damage. Preparation techniques should neither add nor remove damage. A technique to thin out zirconium metal and permit transmission electron microscopy is being developed. The method consists of mechanical polishing and chemical or cathodic etching.

Samples Processed During the Month

Total Samples	851
Total Replicas	39

Photographs

Micrographs	478
Macrographs	122
Electron Micrographs	197
	797

NPR Charging Machine

Fabrication of the four 14-foot rail sections is complete. Installation of these rail sections in 314 Building is 50% complete. Fabrication of the welded truck frames and the nozzle adapter was completed. Machining of the truck wheels is 50% complete. Fabrication of all the shafting for the cross travel drive is 85% complete.

Testing to determine the friction coefficient between the rubber drive roller and the magazine was completed and an informal report was issued. Evaluation of the electric eye and ultra sonic detection equipment is 70% complete.

Preliminary designs were prepared for the charging magazine support to span "C" elevator and the test apparatus for magazine taper to arrest motions of the free piston in the magazine.

NPR Bellows Test

An estimate was prepared for flexure and vibration testing of NPR process tube gas seal bellows. A work order for $4,000 has been received from IPD to perform these tests.

F. W. Albaugh

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PHYSICS AND INSTRUMENT RESEARCH AND DEVELOPMENT OPERATION

MONTHLY REPORT

JANUARY 1961

FISSIONABLE MATERIALS - 2000 PROGRAM

REACTOR

NPR Fuel Temperature Coefficient

Three additional measurements of the change in PCTR reactivity have been made as the fuel in the central test cell of the NPR core was heated. The average temperature of the fuel element was computed by the method of volume-weighting. The fuel element reached average temperatures of 325, 968 and 755°C after being heated for 34, 47 and 35 minutes, respectively. The third measurement was prematurely halted by a reactor scram. The temperature at the boundary of the lampblack insulation rose 12°C during the run. Similar data for the first two runs were not obtained because the thermocouples were not operating.

An effort is being made to get a generalized least-squares program operating. This program will fit the experimental data to the function $\rho_i = \rho_o + \beta (T_i^n - T_o^n)$ and provide the best values of β and n for a given set of data.

The change in PCTR reactivity with a change in the temperature of the entire reactor has also been measured. The data can be fitted with a straight line from 24°C to 28°C. The slope of this line is (-0.67 ± 0.02) ¢/°C.

Exponential Measurements for N Reactor

The change in buckling upon insertion of boron control rods has been measured in the N-reactor mockup. The change in buckling was also measured with no fuel in the pile and one dry boron rod placed in the center. The results are summarized in Table I.

TABLE I

Buckling (10^{-6}cm^{-2})	Enriched Fuel (In or Out)	Rod Configuration	Remarks
-145	Out	No Rod	Diffusion Length Expt.
-277	Out	One dry rod	In center of pile.
116	In*	No Rod	Fuel H_2O Cooled.
21	In	One dry rod	In center of pile.
20	In	One wet rod	In center of pile.
-95	In	6 dry rods	N-reactor control rod spacing

* Fuel in all cases was H_2O cooled.

The wet control rod had water both inside and outside the boron region. The extrapolation lengths used were 1.7 inches side-to-side and 1.4 inches front-to-rear. Thus the bucklings assume no change in radial leakage, which amounts to assuming that the flux distribution is the same as the flux in an infinite medium with rods, weighted by the cosine distribution of the fundamental mode.

Exponential Measurements of Large Diameter Fuel Elements

The cofit computer program used for analyzing horizontal traverse data has been modified to include fast source theory harmonic corrections. One horizontal traverse has been analyzed using the modified program. With fast source harmonics the extrapolation length calculated was 0.7 inches; whereas, with thermal source harmonics the extrapolation length was 2.0 inches. The data were taken in an 8 x 8 foot exponential pile loaded with tube-in-tube natural uranium fuel elements at a lattice spacing of 8 3/8 inches. The neutron sources were clustered around the vertical axis of the pile.

NPR Phase III Fuel Element

A preliminary analysis of the thorium cycle in the Phase III N-reactor was carried out using the Meleager code. Conclusions were:

1. Reactivity loss is not a limiting parameter on the length of an irradiation cycle.

2. Heat rate declines more rapidly than reactivity, and may become limiting at approximately two percent total atomic burnup.

3. Optimum U-235 enrichment level was not determined, but the range 2.1 w/o to 2.3 w/o is indicated as most promising.

4. Thorium metallic fuel appears from this study to be a very feasible choice for high-exposure operation, from the fuel-cycle physics standpoint.

Digital Computer Programs for Reactor Analysis

Development of HFN, the Hanford version of the multigroup neutron diffusion theory code, FN, is continuing. Correction of some input data errors has improved the agreement between HFN calculations and an exact solution to an infinite medium multigroup thermal spectrum test problem. The HFN results are now within 0.5 percent of the exact solution. In view of the special characteristics of this problem, this is considered excellent agreement. A few production calculations have also been run successfully. Results of these calculations indicated that the amount of redundant HFN output could become excessive when several similar cases were run. The code has, therefore, been modified to permit selected portions of the normal output to be deleted. Provisions for calculating detector activities and activity ratios as a function of position are also being incorporated.

Computational Programming Services

A generalized least squares program, described in LA-2367(1), was imported from Los Alamos and modified to work on our FORTRAN monitor system. The test case given in the program writeup has been run successfully. The program uses an iterative technique to least squares fit experimental data to a function of as many as five independent variables. The function to be fitted is specified by the user, who must insert N + 1 FORTRAN instructions into a subroutine, where N is the number of parameters to be determined by the fit. N may be as high as twenty. There are virtually no limits on the form of the function considered. Arbitrary statistical weight may be assigned to each point, and an error analysis is part of the output.

Instrumentation

Cooperative effort with Instrumentation Design, CE&CO, and Instrument Development, IPD, concerning the NPR Fuel Failure Monitor continued. A complete review was made of the mechanical specifications and drawings, and the slow-scan circuitry was completed for test on the KER Loop 1. The slow scan portion consists of a single channel pulse height analyzer, NaI crystal, phototube detector, and necessary addenda equipment. Installation in the test loop will follow fabrication of the necessary shield.

Development work continues on the experimental scintillation Fast and Slow Scan Fuel Failure Monitor. This system is nearly ready for continuous test. The new slip-ring assembly was installed, and tests with it and the NaI crystal and phototube detector were satisfactory.

Accelerated development continues, with one design completed, for a new approach to radiological area gamma monitors. This work is being done for general plant application; however, if successful, it also will be directly applicable to the NPR Area Monitor problem. Because of requirement changes, our original prototype was unsatisfactory for NPR use; however, since no commercial unit of equivalent cost has proven to be satisfactory, the new development was started. The new unit, two of which are in engineering fabrication, is both a multi-range linear and a quasi-logarithmic type to cover all possibilities. The linear ranges will be 0-10 mr/hr to 10 r/hr. In tests, at about 100 r/hr, the maximum phototube anode current is limited to 3 microamperes; thus, the phototube fatigue problem should be negligible. Typical phototube anode current at 2 r/hr is but 0.5 microamperes. The system uses a transistor-driven mechanical chopper, a silicon diode string for quasi-log response, a transistor amplifier, and necessary readout and alarming circuits. The equivalent current chopper noise level is 5×10^{-9} amps. Two weeks of continuous breadboard tests have shown no change in chopper noise, response characteristics, etc.

The NPR prototype Beta-Gamma Air Monitor remains in satisfactory operation using a temporary meter-relay to replace the original poor quality unit. A new meter-relay is on emergency order and will be installed when received. All tests to date on the prototype unit, which uses a transistorized log count-rate meter, have been successful.

(1) Moore, R. E. and R. K. Zeigler, "The Solution of the General Least Squares Problem with Special Reference to High-Speed Computers," LA-2367, March 4, 1960.

Technical support was provided to Equipment Development, IPD, and Instrumentatic Design, CE&UO, concerning NPR reactor instrumentation. Principal effort concerned bid reviews for reactor period monitors, log instrument linearity, hole-coring problems in reactors, octant monitors, and period meters (CGI-806). Planning, circuit details, and guidance advice was rendered on the foregoing. In addition, recommendations were made concerning improvement of the fuel failure detection gamma monitors (CGI-904).

Several high speed transistors, avalanche transistors, and germanium tunnel diodes were tested for best possible rise time. It was hoped one or more types could be found which would be an effective substitute for the EFP60 in fast timing circuits. The best rise time measured was about three nanoseconds, generated by a 2N416 in an avalanche mode of operation. This time is about twice that of an EFP60. The 2N416 would be useful for many applications, except the delay between the trigger pulse and the output pulse is a strong function of trigger pulse height and applied voltage. The gallium arsenide tunnel diodes should be quite fast, and will be tested as soon as they are available.

Fabrication of the experimental reactor pyrometer for moderator temperature measurement is nearly complete. There has been a temporary delay in the work on this unit to allow for parts on order to arrive and to permit fabrication on other customer work. A focusing lens and viewer must still be designed and fabricated but the main unit has been fabricated and only needs assembly.

Some preliminary thought was given to a simple, dependable, high speed period and log level meter. This device would use the principle of the fedback photomultiplier.

Systems Studies

The NPR primary loop has been studied on the EASE analog computer. A series of preliminary studies were made. The system was disturbed with five different ramps in reactivity and the temperature and power transients were observed using two different control systems for the primary heat exchanger, and three different temperature coefficients for both water and metal temperatures.

An analog program was prepared for about one-third of the NPR secondary loop. The secondary loop was divided into three sections to make the initial analog analysis easier.

The NPR pressurizer system is still being studied on the GEDA computer. Enough computer runs have been made for various pressurizer conditions to indicate that the temperature loop, yielding heat transfer through the pressurizer walls, has only a negligible effect on the rest of the problem; the loop has accordingly been removed. The computer runs also indicated that the liquid level controller has a significant effect on the pressurizer operation, e.g., setting the reset too high results in pressure oscillations about the setpoint which grow in amplitude. The final computer runs have been designed to show, among other things, the effect of the liquid level controller on overall operating conditions.

For Reactor Control Studies, the temperature-rod movement data obtained earlier on 100-D reactor were studied briefly to determine the approximate magnitudes of the time constants involved. A considerable difference in the time responses of the

temperature changes due to movements of rod A, as compared to those of rod B, was noted. The cause of this effect has not been studied further as yet due to the press of other work. The time constants associated with movements of rod A correspond rather closely with those shown by the power-rate-of-rise tests. One section of the eight section reactor controller, proposed for the 100-D reactor, will be put on the EASE computer in the near future. This controller consists of an eight point sampling system. If any point is outside the preset limits, the associated rod will drive in or out a fixed amount. The rod will then remain stationary until the scanner returns to its temperature element for another measurement. The system will be a modified on-off controller.

The specifications for a medium-size digital process control computer were written and distributed to the computer study group for comment. Revisions based on these comments were included in a second specification which will be made the basis for a purchase requisition.

SEPARATIONS

Plutonium Critical Mass Facility

Minor Construction (J. A. Jones) personnel have continued work on modifications to the Facility prior to startup.

As requested by the Critical Mass Laboratory Safety Audit Council, and by the AEC in their letter authorizing operations in the Laboratory, a ventilation barrier has been installed across the exterior hallway between the mixing room and change room; a wall and door were used as replacement for the chain barrier originally installed. This modification was required in order to provide a secondary containment area between the mixing room and the exterior of the building.

The process piping changes have been completed now; the lines have been flushed with water and tested under pressure of 60 pounds.

The tanks in the lower portion of the mixing hood were covered by means of a fibre glass process in order to facilitate cleanup from potential leaks in the lines, and to prevent any plutonium from coming directly in contact with the cadmium sheets between the tanks in the event of such leaks.

Glove ports were installed in the critical experiment hood, pump hood, and mixing hood. The pump and mixing hoods were tested for tightness. When under a negative pressure of four inches of water, the leakage rate into the upper portion of the mixing hood was less than two cubic feet/hour; the leakage rate into the lower section of this hood, and the pump hood were both less than one cubic foot/hour.

Some modifications appear necessary to the air balance system in order to maintain the mixing hood at a negative pressure of one inch with respect to the room air, and the room at a negative pressure with respect to the outside.

A chain hoist has been designed and constructed for installation in the top of the critical experiment hood.

Some difficulties are still being experienced with the operation of the valves in the suction header in the mixing hood; these valves have been hard to turn and have a tendency to freeze tight.

Pre-startup check out of the plutonium solution handling system and of the control instrumentation for the reactor assemblies was continued. Scram times for the safety and control rods were measured together with the flux monitoring instrument response times.

Conventional nuclear instruments such as count rate meters and ion chamber current amplifiers are used in flux monitoring channels for the Critical Mass Facility. Measurements have been made of the response times of these instruments in order to estimate the delay which may be expected before initiation of a scram in the event of a nuclear excursion. In this sense, the response time is measured as the time between initiation of a simulated step increase in the flux level and the time of relay opening in the safety circuit controller. (Full shutdown will follow delay due to further relay action, magnet release time, and actual rod falling time.)

The lower limit to response time appears to be a 30 m.s. (milliseconds) delay in the safety circuit controller on all channels.

The response time of the counting rate meters was initiated by turning on a pulse generator. For two linear channels the trip point was set at 90% of full scale. The minimum response time measured was 65 m.s. to 160 m.s. for count rates of 10^6 CPM or more. This time did not depend on range switch setting, but did depend on the time constant switch position. Lower counting rates and range switch settings resulted in longer trip times. For example, on the lower ranges, for step changes to as great as 100 times full scale, the trip time was as long as one-half second.

On the log counting rate channel, the situation was essentially the same. A minimum trip time as low as 45 m.s. could be obtained, but only with counting rates many decades above the trip level.

The linear ion chamber current channel uses a Beckman Model V electrometer. With the trip level again set at 90% of full scale, a test current source was used to provide a step current change. This instrument was disappointingly slow. Minimum trip times were one of four distinct values between 200 m.s. and 900 m.s. The values depended upon the range switch setting and were attained for step changes to 10 times full scale. Larger currents did not result in shorter trip times. The significant point is that on certain ranges, the trip time of nearly one second cannot be improved upon, even for very high fluxes.

The other ion chamber channel uses a log scale instrument having a minimum trip time of 100 m.s. This value was attained only for a many decade step change. For step changes of even two decades, the trip time was much longer, especially in the lower end of the range. (Five seconds for a trip level one-half decade above the initial current.)

Both log channels mentioned have period trips. For the latter instrument, the trip time was gratifyingly short (45 m.s.) with the trip level set for 10 second periods. The count rate channel had a period trip with a deliberate time delay of about 1.5 second minimum. This is being removed and trip times remeasured.

The time for the safety rod to fall has been remeasured with little difference over the preliminary values reported last month. The value obtained was 270 m.s. with ± 5 m.s. RMS deviation. This is the time from trip in any channel (the end of the instrument response times above) to the time the safety rod actuates the full in limit switch.

Control and Safety Rod Calculations

For the conduct of the criticality experiments with plutonium solutions, it is planned to limit the control rod worth to values less than one dollar (about 75 cents) and to have the safety rod worth be about ten dollars. A series of calculations have been made utilizing the AIM-6 multigroup diffusion code (18 groups) to define the rod dimensions for which the prescribed rod worths are met.

A diffusion calculation would normally give very poor results for black or nearly black rods; however, satisfactory results can be obtained by treating the rod as a free surface having the following boundary condition:

$$\frac{d\phi_i}{dr} + \omega_i \phi_i = 0,$$

where ϕ_i and ω_i denote the flux and extrapolation distance, respectively, of the i^{th} group. The values of ω_i will be negative for an internal boundary. The extrapolation distances are chosen so that the flux shapes in the medium surrounding the rods are accurately defined.

The safety rod calculations were made with the assumption that the rods were black to thermal neutrons (energies below 0.4 ev) and gray to neutrons above the 0.4 ev cadmium cutoff. The method of E. R. Cohen(1) was used to calculate the extrapolation distance for black cylinders and the method of B. Davison and S. Kushnericek(2) was used for gray cylinders.

The control rod was taken to a stainless steel rod that was gray to neutrons of all energies.

All calculations were carried out for a 13-inch diameter bare cylinder with the rods fully inserted. The results of the calculation are given in the table below.

CONTROL AND SAFETY ROD WORTH IN DOLLARS

Rod Radius (cm)	At Pu Density of 87 g/cc	At Pu Density of 128 g/cc	At Pu Density of 258 g/cc	At Pu Density of 495 g/cc
0.5 (control)	2.37	1.84	1.15	0.79
0.5 (safety)	5.16	3.94	2.31	1.35
0.75 (safety)	6.93	5.41	3.31	2.06
1.00 (safety)	8.80	6.74	4.38	3.47
1.50 (safety)	13.13	10.29	7.11	5.89
2.00 (safety)	18.00	14.40	10.36	8.92

(1) Flatt, H. P. and D. C. Baller, AIM-5, A Multigroup, One-Dimensional Diffusion Equation Code, NAA-SR-4694.

(2) B. Davison & S. Kushnericek, Linear Extrapolation Lengths for a Small Black Cylinder with a Small Air-Gap and a Small Imperfectly Absorbing Cylinder [illegible] and without an Air-Gap, AECL-124.

It is to be noted from the above results that a 2 cm safety rod will have a sufficient strength to serve over the range of experiments that have been planned. However, the control rod will only suffice for plutonium solutions of higher concentrations. The 0.5 cm steel rod is the practical minimum physical limit for the control rod. It, therefore, will be necessary to utilize hollow rods of varying thicknesses to obtain the desired rod strength of about 75 cents.

PuO_2-Plastic Mixtures for Criticality Experiments

The 234-5 Development Operation reported on the results of further stability and gas evolution tests with PuO_2-polystyrene compacts; during a four week period no gas evolution was observed from a sample of PuO_2-polystyrene with a nominal H/Pu atom ratio of 15, and a Pu content of about 1500 gm/l of mixture.

Current plans are to use PuO_2-plastic mixtures in criticality experiments with a split half machine to obtain data relevant to precipitates of Pu and PuO_2 slurries.

Orientation and Training Sessions

In connection with plutonium handling operations in the Critical Mass Facility, a series of orientation and training sessions were begun to familiarize the operating staff with the contamination hazards involved in handling plutonium. The series consists of five sessions, each one hour in length, with one session each week. Primary emphasis is on contamination control and radiation work procedures.

Data Correlation - Criticality Calculations for Nuclear Safety

Several curves, representing properties of various homogeneous systems, have been calculated by means of the 9-Zoom multigroup diffusion code (18 energy groups). These curves include: Critical mass versus plutonium concentration for Pu-H_2O, PuO_2-H_2O, Pu-Al alloy, and a special PuO_2-H_2O slurry.(1) The range of concentrations which were used resulted in neutron energy spectra in the range from all thermal to all fast. Some difficulties were encountered in attempting to represent such a wide range of systems with a single set of multigroup parameters. In the very fast systems (solid plutonium) it was necessary to modify the high energy transport cross sections in order to obtain agreement with the experimental value of the critical mass.

The difficulties with the 14-inch spheres of the P-11 project have now been resolved, and satisfactory agreement has been obtained between the calculated and experimental results for the reflected sphere systems. Some further checking with a more extended range of H/Pu ratios and various poison concentrations is in process.

Critical parameters for PuO_2 with a maximum density of 5 gm Pu/cm^3 are given in the following table. These calculations were made for Pu density - H_2O moderation relationships measured with PuO_2 from continuous calcination of plutonium nitrate solution.(2)

(1) Letter to P. F. Gast from V. R. Cooper, dated January 20, 1961, and entitled "Nuclear Safety - Consultation - Safe Cylinder Size for Plutonium Oxide."
(2) H. W. Crocker, "234-5 Development Operation," Private Communication."

TABLE I

H/Pu (Atom Ratio)	Pu Density (gm/cc)	Critical Radii: Bare Sphere (cm)	Reflected Sphere (cm)	Infinite Cyl.(Bare) (cm)	Infinite Cyl.(Refl.) (cm)	Critical Masses: Bare Sphere (Kg Pu-239)	Ref. Sphere (Kg Pu-239
.01	4.2	16.2	11.6	11.7	7.1	87.7	32.2
.7	4.7	14.5	11.58	10.5	7.0	63.0	32.3
1.09	4.7	13.61	10.2	9.9	6.3	52.5	22.1
2.35	4.3	12.9	9.87	9.4	6.1	38.9	17.3
4.21	3.4	12.8	9.86	9.3	6.1	30.1	13.7
7.21	2.46	13.3	10.18	9.7	6.4	24.1	10.9
11.41	1.77	13.7	10.55	10.0	6.6	19.1	8.71
20.41	1.11	14.4	11.15	10.5	7.1	14.0	6.45

Notes: (1) Critical radii are determined to the nearest 0.5 millimeter and given to the nearest millimeter.

(2) No account is taken of Pu-240.

(3) No correction was applied for Pu-239 fission resonance self-shielding; the critical masses are therefore underestimates by some small amount; critical radii are, by the same token, the same kind of underestimates.

Interaction of Subcritical Systems

The investigation of the interactions between subcritical fissile units using variational methods has continued. Attention has been directed to improving the trial function for the thermal flux in the two-group approximation to Stuart's method. A measure of the improvement is the closeness of agreement between the exact eigenvalue and the eigenvalue calculated from the variational principle using the trial function. Because its exact eigenvalue is easily found, the simple case of a single unit in an infinite moderator is being used to test the trial functions. First efforts to use trial functions in the core region different from Stuart's constant function were described last month; the improvements were very slight. A further improvement tried this month was to extend the trial function into the moderator. Results of this trial were unexpected: the calculated eigenvalue was less than the exact eigenvalue, an apparent contradiction of this variational principle. The difficulty was traced to a misinterpretation of the variational expression being used, which required that only core region functions appear. The mathematics of the difficulty is related to the difference between the adjoint to the integral of the thermal flux equation and the integral of the adjoint to that equation. The consequence is that improvements in the trial function need be sought only in the core.

Miscellaneous Experiments for Nuclear Safety Specifications

On January 4, 3.9 Kg of highly enriched uranium (93% U-235) were received from the ORNL Criticality Group; the uranium was in the form of highly concentrated UO_2F_2 solution (about 950 gm U/l). The uranium, which was obtained on a loan basis, is to be used in k_∞ measurements in the PCTR for determining the limiting just critical concentration of U-235 in an aqueous solution. The results of these

measurements will be compared with those reported by ORNL, and will serve as a further cross check between the two laboratories. The measurements will also provide another "known value" for checking the PCTR method.

Final preparations were begun during the latter part of the month for the experiment in the PCTR. The UO_2F_2 received from Oak Ridge for the experiment was diluted down from its original concentration of about 950 g of U/l to the proper concentrations for the k_∞ measurements in the PCTR--13 g of U/l for the buffer tanks and 11, 13, and 15 g of U/l for the three core tanks, respectively. The experimental tanks were filled with these solutions and sent to the 305-B Building. There upon it was discovered that the three core tanks were beginning to leak through defective welds. New core tanks were constructed and the solutions from the defective tanks were transferred to new tanks. At this point, the front end buffer tank was found to be leaking. A replacement for this tank was then obtained and filled with solution in the preparation for the measurements.

Criticality Hazards Specifications

Nuclear Safety Specifications for HLO

Three specifications were issued for Critical Mass Physics. These were:

C-8, Rules for Loading, Transporting, and Storage of Mark III Vessels Containing up to 11 g Pu/l as $Pu(NO_3)_4$

C-9, Rules for the Loading, Transporting, and Storage of k_∞ Measurement Vessels Containing up to 16 g/l UO_2F_2 (93% U-235 Enriched)

C-10, Experimental Determination of the Limiting Concentration for U-235 Solutions

These specifications cover the handling and storage of dilute $Pu(NO_3)_4$ and UO_2F_2 prior and during the k_∞ measurements on these solutions in the PCTR.

Comments were submitted to the Plutonium Metallurgy Operation concerning the nuclear safety of storing plutonium metallographic samples in the 231-Z Building.(1) These samples, which consist of a 20 gm piece of plutonium mounted in a lucite block, have an H/Pu ratio of 15-20. For storage each sample is enclosed in a three-inch diameter by 1-1/2-inch high metal can. Limits for storage were recommended.

Evaluation for Nuclear Materials Operation

The offsite shipment of 149 Kg of 1.8% U-235 enriched UO_2 fuel elements and 116 Kg of 2.6% U-235 enriched UO_2 fuel elements was reviewed for the Nuclear Materials Operation.(2) These fuel elements were contained in six birdcage-type barrels. Conservative estimates indicated that the quantities represented not more than

(1) Letter from C. L. Brown to R. D. Nelson, "Comments on the Storage of Metallographic Samples," January 31, 1961.

(2) Personal communication with F. J. Zelley.

0.70 and 0.86 of a minimum critical mass for the two enrichments, respectively. NMO proposed making three shipments of two barrels each by common carrier, which is adequately safe.

Mass Spectrometry

The mass spectrometer for this program has been used to study some previously observed effects on ion beam size, as observed at the collector slit of the spectrometer. The source of these effects has been isolated to the ion source, but the causes have not been completely determined or eliminated as yet. An increase in the observed beam width seems to arise from a spread in the ion energy which appears to be associated with variations in the source electrode potentials, possibly due to electrical leakages. During the course of looking for the source of the difficulties, several peaks in energy have been observed, and beam widths up to three times larger than allowed for monoenergetic ions and source collimation were observed. Further studies of these effects are in progress.

NEUTRON CROSS SECTION PROGRAM

Low Energy Neutron Cross Sections

An investigation of the neutron beam facility for the crystal spectrometer at 105-DR was made during the month. The investigation showed the deterioration in time of the masonite sections of a step plug contained in the interior shielding. Some decomposed material which had been restricting the neutron beam was removed from the step plug. Following reassembly and alignment of the spectrometer system measurements showed a fairly uniform neutron beam and normal beam intensities. Measurements with the spectrometer are now in progress to determine the burnout of cadmium samples by monoenergetic neutron transmission measurements. These cadmium samples are from a control rod of "C" Reactor. The results will be used by IPD personnel to develop methods of calculating the burnout of other reactor control rods.

Slow Neutron Scattering Cross Sections

The series of inelastic scattering measurements at 0.147 ev initial neutron energy has continued. A thin sample run was made to determine multiple scattering effects.

An attempt was made to obtain the spectrometer sensitivity at 0.147 ev by measurements of the elastic peak of a room temperature vanadium sample. However, these and other subsidiary experiments show that appreciable phonon scattering is included in the broad resolution function. Thus, to use vanadium as a standard sample, it will be necessary to cool it well below its Debye temperature to suppress the phonon scattering. Design of a liquid nitrogen cooler is underway.

INELASCAT, the code which processes inelastic scattering data from the three-axis neutron spectrometry is in the process of desk-debugging. Desired changes have required some major revamping of input-output coding. Over-all effort on this code is about 35 percent complete. A pair of utility routines, RTBX/WTBX, to facilitate handling of data such as the results from INELASCAT, have been written and are being debugged. These are general purpose routines which write binary data to a tape, which can then be read back for further processing or for punched offline for future processing. The records written to the punch tape conform to

FORTRAN specifications for binary cards. The facility for such offline punching is a recent addition to our FORTRAN system.

Fast Neutron Cross Sections

Most of the month was expended on overhaul and development of instrumentation. The RF deflection oscillator was altered to permit use of the time-mark system without interfering with normal use of the Van de Graaff, and extensive checks were made on chronotron operating conditions. A number of adjustments and modifications were made to improve stability and reliability of the chronotron.

Steps have also been taken to reduce background in cross section measurements. A pulse-shape discrimination circuit which rejects electron counts has been tested and should help materially in reducing background. For the same purpose 1-1/4 tons of lead bricks have been assembled for a bulk shield.

All of the samples ordered for the first phase of the total cross section program have now been received.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE

PRTR Startup

PIRDO personnel participated in the second series of critical tests during the month. The tests were terminated January 31. All tests were completed as planned except the temperature coefficient and cell traverse experiments. It is planned to do these experiments before the power tests are begun. A total of 200 gold foils which were irradiated in the Critical Tests were counted during the month.

The experimental data are being analyzed by personnel in the Reactor Engineering Development Operation. It appears that part of the over-prediction of the effective multiplication constant for the PRTR is due to too high reflector savings calculated using a two-dimensional model. Also, earlier indications that the PRTR shim system might be weaker than predicted have not been borne out by later measurements. It now appears that the maximum strength will be even slightly greater than 130 mk, the calculated value.

Low and High Exposure Plutonium Lattices

A scheme for determining the change in α upon poisoning a Pu test lattice has been formulated. It will be tried first with the data from one of the low exposure Pu lattice experiments. The spectrum is assumed (cf. HW-64580 B, p. 3) to be a sum of four terms, namely, a Maxwellian spectrum, a Maxwellian absorption spectrum, a Hurwitz spectrum, and a Hurwitz absorption spectrum. The unknown coefficients are to be found by comparing the activity predicted for a detector using the assumed flux with that observed experimentally for both bare and cadmium covered foils.

Further work has been done during the month on planning new PCTR experiments. The experiments listed below are under consideration as well as those discussed in the last monthly report.

a) A measurement of the rethermalization cross section for aluminum.

It may be possible to measure this cross section by heating an aluminum rod in a graphite core, and measuring the reactivity change which results as a function of temperature. It is not yet clear whether or not this experiment could be interpreted satisfactorily.

b) A measurement of the Pu-240 effective resonance integral for single Pu-Al rods of various sizes containing various amounts of plutonium. This would be a relative rather than an absolute measurement, and the standard would be the dilute resonance integral. The experiment would be done by measuring the change in reactivity which would occur when the various rods (cadmium covered) were inserted into the PCTR core. A complicating factor in the perturbation theory interpretation of this experiment is the reactivity effect of the Pu-239, particularly for neutrons near the cadmium cutoff.

c) A measurement of the total temperature coefficient for a PuO_2-UO_2 lattice which has a large lattice spacing. This experiment is the most difficult of the group, but the recent PCTR modifications would help. In this scheme, a single hot lattice cell would be inserted very rapidly into the PCTR cavity, and a reactivity measurement would be made. This would be repeated as a function of cell temperature. The problems are in properly handling the flux and adjoint matching, and in getting the hot cell into and out of the PCTR rapidly enough.

Neutron Rethermalization in Graphite and Water

The original goals of these studies of the space-energy distributions of thermal neutrons in graphite and water systems with a discontinuity in the physical temperature were: (a) to determine, from activation experiments with 1/v detectors, the rethermalization cross sections of graphite and water within the frame work of a simple few group diffusion model, and (b) to attempt to verify the model through the comparison of experimental and calculated activities of non-1/v detectors.

Goal (a) has been achieved to a degree which is presently acceptable. The rethermalization cross sections of graphite have been found to a precision ± 10% and those for water to a precision of ± 25%. A report on this work has been prepared for the October, November, December, 1960, Quarterly Report.

Work towards the achievement of goal (b) is in progress.

Within the framework of the simple few group diffusion model the data have been analyzed best, in the least squares sense. However, the theoretical fits to the experimental data are not within the statistical precision of the data. It has tentatively been concluded that the model is somewhat inadequate. Various modifications of the model are being considered which are based upon a re-evaluation of the derivation of the few group equations.

An informal report entitled, "The Variational Method and Reactor Physics," HW-68284, was written. This report discusses the mathematical background required in applying variational methods to reactor physics. The multigroup approximation is used as an example. Emphasis is placed on the distinction between overlapping and non-overlapping groups, and the advantages and disadvantages of each are discussed.

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The work reported on in December, 1960, has been prepared for inclusion in the October, November, December, 1960, Quarterly Progress Report under the titles, "Overlapping Group Spectra and the Few Group Equations," and "The Two Group Approach for a System with Temperature Discontinuities."

Code Development

RBU

The revision to the basic library (making use of resonance parameter tables optional) was completed. A short report explaining the format of the library was written and distributed to those persons active in the Hanford cross-section committee.

An edit routine, now 50% complete, is being written to produce: (1) a listing of the basic library complete with headings, etc.; and (2) a tape from which FORTRAN or SOS cards may be punched producing a new card library in more readable form. The listing is to be distributed to the cross-section committee as a reference for revisions and additions to existing information.

Good progress was made in the calculation for the NPR cell. At the end of the month preliminary Monte Carlo results had been computed, but further revisions of problem specifications are required in order to proceed to the diffusion and burnup codes. An improved system of tallying tape contents and positions was added to the Input code, and minor revisions were also made in the Pre-Monte Carlo and Output codes.

GPR

Modifications were made to increase speed and give more correct results on non-recycle cases.

MELEAGER

A method for automatic determination of neutron spectrum in graded-irradiation cases was developed. An edit routine for computing polynomial approximations to output data was written.

The modified self-shielding formulation described in previous reports was incorporated into the code and is now in routine use. Results appear similar to earlier ones, with the main changes occurring in the Pu-240 effective resonance absorption.

Instrumentation and Systems Studies

Investigations were started concerning gamma energy spectral measurements of fuel rods containing UO_2 and PuO_2 to determine the possibility of locating improper segregation of small amounts of PuO_2 in the UO_2. Spectra obtained using the multi-channel analyzer indicated possible measurement feasibility. The fuel elements tested to date were of the UO_2 only and PuO_2 only types. Further tests are to be made with typical elements with both oxides in the usual proportion. Such tests will determine the extent of the real problem, and the possible methods of scanning to be employed.

Laboratory tests of the "last ditch" reactor (PRCF) safety-fuse devices indicate the enriched uranium fuse element temperature will be about 85°F at a neutron flux level of 10^9 nv. The necessary enriched uranium has been ordered for fabrication of experimental units.

All necessary preliminary work has been completed concerning the use of a Cs^{137} source for measurement of UO_2 packing densities in Zircaloy tubing of various sizes. Necessary instrumentation design details can now be completed when required.

The PRTR instrumentation system was inspected and preliminary estimates were made concerning the problem magnitudes involved. The PRTR Fuel Failure Monitor will be received from the off-site manufacturer shortly. Since the system is not in proper operating condition, it will have to be modified before use with the reactor.

A new BF_3 ionization chamber for use with the PRTR neutron lifetime tests was fabricated and tested during the month. The BF_3 filling pressure used was one atmosphere. The center electrode diameter is 1/8 inch and the chamber O.D. is 1/2 inch. The chamber was installed in the PRTR vertical traverse monitoring hole. Preliminary tests made during several period runs on PRTR show that the chamber sensitivity is greater than that of the previous model. An accurate calibration of the magnitude of this improvement has not been made but the factor is at least two. In addition, the chamber has been located closer to the center of the reactor to increase the pile noise component of the signal. The combination of greater chamber efficiency and a more favorable position are expected to yield an adequate pile noise signal. Several changes were made in the amplifying equipment and the cables connecting the preamplifier to the control room equipment. A significant reduction extraneous hum and noise was obtained. The equipment is now installed in the PRTR and is expected to be used as soon as the Kinetics Experiment Critical Test is scheduled.

An attempt was made to measure the neutron lifetime of the TTR (Thermal Test Reactor). The data obtained, however, were not conclusive due to difficulty experienced with extraneous electrical interference. Another measurement will be made as soon as equipment modifications can be completed.

The PRTR Critical Facility Analysis on the analog computer was completed this month. The results were satisfactory. A new technique was employed in the completion of this work. An attempt was made to develop an analog circuit which would automatically run the reactor simulation through all necessary decades of power level. This circuit included the use of analog memory, automatic computer mode switching, and a logarithmic simulation of the reactor temperature loop. Modifications necessary to provide the analog memory functions were made on the EASE computer. The analog memory and the automatic mode switching techniques performed very well. Trouble was encountered with the logarithmic portion of the temperature loop. This was due to the limitations of the diode fixed function generators employed in the circuit. A satisfactory method of closing the temperature loop in a multidecade reactor simulator has not been developed. More development work will be necessary for this technique. The use of analog memory, however, eliminated the necessity of reading out the values of the delayed neutron groups and the fuel temperatures at the end of each decade. It also automatically provided the proper

initial conditions for the beginning of the next higher decade. It is estimated that the use of this technique resulted in a time saving of approximately 75 percent.

The PRTR Gas Annulus Measurement probe has been modified, reassembled, and the calibration spot checked in preparation for remeasuring the apparently misaligned process tubes in the PRTR. The probe was modified to provide a more rigid cable clamping fixture, and since its performance has been satisfactory, the final waterproofing was also accomplished. Further hot water and radiation tests are planned to provide design data for later probe designs, but the prototype probe assembly will remain operational until the question of including a borescope in the tube inspection system has been resolved.

In the development of an instrument for measuring the wall thickness of PRTR process tubes, difficulties are being encountered in obtaining proper acoustic coupling between the moving ultrasonic transducers and the inner tube wall. A complete probe redesign may be required to accommodate transducers having larger surface areas. A calibration technique was developed for the Vidigage to be used with this probe and further development is required on the recorder system.

NONDESTRUCTIVE TESTING RESEARCH

Circuit changes were made to increase the sensitivity of the six-channel pulse amplitude sampling circuit used in sampling the outputs of the orthogonal filter incorporated in the broadband eddy current equipment. It was found that increased sensitivity was needed to read small differences obtained for small changes in test specimen parameters.

As indicated in the previous report, attention is now directed to the determination of the requirements of a network which will transform the orthogonal filter sampled outputs which represent the orthogonal components of the system response vector, into measures of the individual test specimen parameters. This part of the problem is being attacked by two methods: (1) analysis of empirical data obtained by varying the test specimen parameters and reading the orthogonal filter sampled outputs to determine the general type of transforming networks required, and (2) to design the transformation circuits based on observation of the behavior of the sampled outputs for various test specimen parameter conditions. In each instance the networks will be built and then tested. In the second method, network adjustment will be empirically determined. It is expected the networks will consist of combinations of linear and non-linear elements.

Work on both approaches is continuing. Additional data and experience with the equipment are required to satisfy these needs, thus more measurements will be made for test specimens having a range of electrical conductivities and layer thicknesses.

Report HW-67658, "Multiple Parameter Eddy Current Nondestructive Testing Device," was completed and issued. It was incorporated in a report of invention which has been designated HWIR-1346.

A formal report manuscript, "Broadband Electromagnetic Testing Methods, Part 2 - Signal Analysis," HW-67639, written jointly by H. L. Libby and C. W. Cox, was completed and arrangements were made with Technical Publications for issuance.

The prototype matching transformer and single-turn work coil, developed in the laboratory for use with a 10 KC, 15 KW induction heater during heat transfer testing of fuel elements, were rigidly mounted on the scanning lathe in preparation for heat transfer testing of bondtest reject production fuel elements. Sixty-three reject K-IV-N fuel elements were obtained for this purpose. Heat transfer tests of the first few of these indicated uniform fuel-core-to-jacket thermal impedance, within the limits of sensitivity of the equipment. This equipment is capable of detecting heat transfer defects in the bonds equivalent to circular mica-produced voids 3/8 inch or larger in diameter. Complete ultrasonic data will be required for these fuel elements to allow a comparison between ultrasonic and heat transfer characteristics. Arrangements for such ultrasonic tests have been made with Testing Methods, FPD.

A refrigerated type PbSe infrared detector has been obtained for use in the Model III radiometer. Application of this detector, in connection with the method of compensating for emissivity variations now under development, should allow an increase in sensitivity of the heat transfer testing equipment. An analog multiplier for application in the emissivity compensating device has been ordered.

Specifications for a flying spot type area mapping recorder have been written. This recorder will yield an over-all picture of heat transfer uniformity from tests on a large number of fuel elements.

Tests of the 40 KW plasma jet arc indicated power input to an aluminum surface was reproducible within about ± 5 percent for a power input to the arc electrodes of 18 KW. These tests also indicated approximately 22 percent of the power furnished to the arc electrodes was transferred to the surface of a moving cylindrical test piece. This efficiency is better than was indicated in initial tests using a flat stationary surface. An adjustable holder for mounting the plasma arc on the heat source carriage of the scanning lathe has been fabricated.

Mica-produced voids 1/2 and 3/8 inch in diameter in an AlSi bonded fuel element have been detected by thermal methods using an inductive thermometer as a temperature indicator. These voids have been detected by an ice cooling method and by a plasma jet heating method. In the ice method the fuel element is heated to 100°C, then rotated and scanned by the inductive thermometer probe while being cooled by ice in a region adjacent to the probe. Some spurious indications are obtained in both methods due to vibration of the probe. This effect is increased due to a change in test probe temperature during a run which detunes the probe and thus would require a readjustment of the probe vibration discrimination circuits for optimum performance.

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transfer. This indicates the preheating of the fuel elements should not exceed 100°C. The loss in sensitivity might be compensated by precooling the ice well below 0°C. Cooling the fuel element with liquid nitrogen gave spurious results, probably due to variation in cooling rate caused by formation of gas and boiling.

NEUTRON FLUX MONITORS

Investigations continued concerning plutonium alloy, in-core, neutron flux monitors. Computer (IBM-709) studies have indicated the theoretical possibility of obtaining a detector lifetime of 20 months with a variation in detector efficiency not exceeding ± 2 percent. This lifetime "value" was for a U-Pu isotope composition of $U^{238}Pu^{239}Pu^{240}Pu^{241}$ in initial relative amounts of 44:0.9:0.45:0.215, respectively, and with conditions as follows:

1. Constant neutron flux level of 5×10^{13} nv;
2. A graphite temperature of 750°K;
3. An epithermal neutron ratio (r) of 0.075;
4. Use of Westcott cross sections.

Additional calculations have shown that, for a 2 cc ion chamber with 1 mg/cm^2 of the forestated fissile material as a coating and with a neutron detection efficiency of 10 percent, a signal-to-noise ratio of about 100:1 can be obtained in the presence of a gamma level of 10^8 r/hr at the stated neutron flux level. A large number of computer run studies have been made for various fissile material isotopic concentrations and for various reactor operating conditions. In addition, a plan has been made to obtain information concerning the use of small ion chambers which are similar in size to those proposed for Pu-U work, and associated cables in actual reactor use. The test chambers, which will give the necessary information, are being installed. This information will be used for the later design of actual U-Pu fissile-material-containing chambers as the experimental part of the program. Calculated and investigative results to date indicate good feasibility for the U-Pu fissile material approach for extended lifetime in-core flux monitors.

PHYSICAL RESEARCH - 5000 PROGRAM

Mechanism of Graphite Damage

The equipment for altering the high vacuum system of the electron Van de Graaff has not yet arrived though it is expected soon. Work continued on planning experiments to be carried out as soon as the alterations are made.

BIOLOGY AND MEDICINE - 6000 PROGRAM

ENVIRONMENTAL SCIENCES

Atmospheric Physics

Investigations continued into the theoretical formulation of atmospheric diffusion-deposition equations to guide analyses of the 1959 field test data. Processing of the large number of meteorological and dosage measurements obtained during the 1960 series of atmospheric dispersion experiments was begun. These

data constitute a valuable addition to the limited data obtained earlier for studying the deposition phenomena. Reduction of temperature, wind direction and wind speed data from the 410-foot Metecrology Tower was 85 percent completed, and that from the portable mast was completed and prepared for keypunching. The dosage measurements for 16 field tests were transcribed to punched cards in preparation for reduction on the IBM-7090 computer.

Meetings were held with personnel of the Ballistic Missile Division and Geophysical Research Laboratories, U. S. Air Force, to detail plans for our assistance in conducting atmospheric dispersion tests at two rocket launching sites and one Air Force Base. The fluorescent tracer system perfected at Hanford will be used for these studies. Our participation will consist of technical test direction, Field Engineering Consultation and sample assaying. Equipment lists and procurement schedules for material peculiar to the tracer system were prepared. Air Force owned sampling equipment was prepared for offsite shipment. (Sufficient equipment will still remain at Hanford to conduct the local field program.) The work will require approximately 18 months to complete. Data collected during these experiments will comprise an important addition to the Hanford data for evaluating topographic influences on atmospheric dispersion patterns.

In a joint effort with Radiological Chemistry, analytical techniques were developed for quantitative measurement of two tracer materials, zinc sulfide and fluorescein, when collected simultaneously on the same membrane filter. Methods of dispersal during actual field trials remain to be investigated. The principal initial use of the technique is for simultaneous release of a different tracer at each of two levels on the Meteorology Tower to study the effect of height of release on ground level dosage patterns.

Analysis of 2 minutes of record from the wind component meter by hand calculation methods was begun, in order to evaluate the data recording requirements of the instrument. Tape recording methods compatible with the analog computer input requirements were investigated.

DOSIMETRY

Another Zn-65 calibration was made to provide more information about the chair position for counting and to determine the usefulness of the scanning method. Data obtained for the chair position agreed with earlier results in showing a gradual change in sensitivity with time. The scanning method of counting gave results that were constant within ± 5% with time.

An experiment to see if we could detect the uranium in an individual known to be contaminated gave no positive result.

The positive ion Van de Graaff was shut down for three and one-half weeks for semi-annual and annual maintenance. After this period the accelerator worked satisfactorily.

Studies continued on the properties of BF_3 counters after irradiation with high doses of photons. Slightly smaller effects were noted in a different counter from the one studied last month.

Theoretical calculations of the efficiency of the Perlow spectrometer were shown to agree with experiment within about 15%. This is sufficient for planning experiments. Experiments were conducted to determine the efficiency of the spectrometer for neutrons coming from undesired directions and for locating the effective center of the spectrometer.

The exit canal for the helium ion source that looked promising last month failed after twenty hours in a life test. Another canal was designed and built and is still operating satisfactorily after seventy hours.

The leakage of the tissue equivalent chambers was improved by use of better insulators. While still filled with air the chambers were checked against a PuBe source and seemed to be all right. They are now ready to be filled with tissue equivalent gas.

One of our scientists was asked to serve as a consultant to the Defense Systems Department of the General Electric Company in detailed planning of a radiological testing facility for the United States Army at their Dugway proving ground.

INSTRUMENTATION

All necessary development work was completed on the scintillation alpha air monitor, using coincident-count techniques, for detecting airborne alpha contamination. The experimental instrument has successfully alarmed in each test on an equivalent continuous Pu^{239} air contamination level of 2×10^{-11} μc/cc (10 MPC) in approximately 60 minutes. The tests were made with the alarm level set to not alarm on the highest radon-thoron concentration levels anticipated in actual use. Similar tests showed an alarm time of about four minutes for equivalent continuous air concentrations of 2×10^{-10} μc/cc of Pu^{239}. No other HAPO-type Pu^{239} alpha air monitor will reliably alarm under laboratory conditions in continuous levels of less than about 6×10^{-11} μc/cc. The best HAPO alpha air monitor now in field use will alarm, reliably, in about 20 minutes on a continuous contamination level of about 10^{-10} μc/cc. All such installed units are ineffective below the 10^{-10} μc/cc level. Fabrication continues on one prototype unit.

A keyboard was installed in the whole body counting facility, making possible the manual entry of data into the core memory of the multichannel analyzer. The development of the required circuits made use almost entirely of modifications of the timing sequences of functions already present in the analyzer. Through the use of the keyboard, calendar and personnel data may be transferred along with counted spectra onto a permanent magnetic tape record.

Work was started for the Radiation Protection Operation towards development of a system to solve a set of four or more simultaneous equations relating to the truecount contributions of individual isotopes to a pulse-height spectrum. The arithmetic operations will be automatically programmed and the system must be able to acquire spectrum data directly from the multichannel analyzer memory.

An experimental servo-controlled gamma beam scanning mechanism was completed, delivered, and satisfactorily tested at the reactor areas. This instrument, stepwise, covers 121 measurement points in an 11-by-11-inch matrix. The servo

system moves a lead-collimated detector head containing a CsI crystal and a phototube on a track system to the 121 points. Phototube pulse information from the scanner drives a multichannel analyzer. This system expedites gathering of data needed for improvement of existing reactor shields and also substantially reduces radiation exposures to personnel engaged in these studies.

A useful and reasonably reliable theoretical model was devised concerning energy storage, fading of stored energy, and various luminescent characteristics of the CaF_2:Mn dosimeters. This model is being used to guide experiments towards reducing the stored energy loss of the dosimeters from the present loss-rate of 10 percent per day. Better circuitry techniques have considerably reduced the readout noise level which was hampering detector development. Investigations continued concerning the use of narrow pass-band interference filters to reduce black-body radiation noise from the metallic disc on which the CaF_2:Mn phosphor is mounted. In addition, the metallic discs have been redesigned to eliminate sharp corners and edges which have, possibly, been contributing to noise at the high temperatures necessary for readout of the dosimeters. Experiments, to date, indicate the dosimeter optimal phosphor grain size should be 10 to 50 microns in diameter, and adherence problems of the phosphor binder to metal disc have been solved by a baking technique. The "art" of successful hermetic sealing of the glass-encapsulated dosimeters has developed to the point of negligible damage from sealing. The induction heating method of obtaining light readout information from the dosimeters has proved quite successful except for minor magnetic field interference with the phototube.

A new transistor and diode circuit was devised, and an invention report submitted, concerning a logic circuit called an Exclusive-Or type. This circuit, particularly useful for computer work, provides an output signal only if one of the input signals is valid.

Investigations continue concerning the use of cross-correlation methods applied to low gamma energy (5 to 50 Kev) analysis. An electronic switch was devised and is used with an operational amplifier for integration. The system materially reduces noise problems to gamma energy levels of less than 5 Kev. Stability of net signal readout was obtained by synchronizing the electronic gate with the rotating segmented absorber, which is between the Pu^{239} source and the NaI detector. The gate output signal drives two circuit channels with one containing an emitter follower and a monostable multivibrator to produce a four-microsecond output pulse. The second channel contains an inverter, a multivibrator, and an emitter follower to produce a pulse identical, except polarity, to the first channel. A dual logarithmic response count-rate meter is then used to indicate the two-channel information. The count-rate meter has a net-ratio center meter to indicate the ratio of the two signals. Results to date are very good with a marked reduction in noise (electronic plus background) levels. Experiments will continue.

Investigations and experiments continue concerning miniature alarming-type dosimeters for personnel use. A three-terminal type ion chamber is being experimentally fabricated. This will permit nondestructive readout of charge. Standard techniques using regular ion chambers and electrometer tubes are no

good as stable dosimeters for the levels involved (0-200 mr) because of the inherent leakage problems. Other experiments continue with the pencil-type ion chamber unit employing light illumination of the chamber fiber, a CdS light detector, and associated transistor circuitry for alarming. The system performs well for gamma dose rates below about 500 mr/hr; however, at higher dose rates, the fiber moves so fast, an "alarm" signal may be missed. Experiments are being conducted to insure "fail safeness" to 10 r/hr dose-rate levels minimum.

An experimental mechanical rate-of-change mechanism has been devised for use in alpha and beta gamma air contamination monitors. The device consists of a timing motor, gear reducer, slip ring, unidirectional clutch, and a stepping motor. The stepping motor is driven by pulses from the amplifier which receives pulse information from the radiation detector. In operation, if the stepping motor rotates faster than the timing motor, contacts close causing an alarm. If the timing motor tries to rotate faster than the stepping motor, the special clutch slips. Thus, in effect, if the "buildup" of contamination on the air filter viewed by the detector is greater than the particular selected rate, the alarm will actuate. Adjustments are incorporated to just prevent alarming for normal radon-thoron background buildup. Other air monitoring investigations concern the use of moving-tape filter heads with one prototype instrument using this type of head now in fabrication.

Experimental transistorized circuitry was devised to permit the driving of standard one-milliampere moving-coil chart recorders to full scale in 0.5 seconds. This speed is needed for use in airplanes for radiological survey use. The developed circuitry will be used with the previously developed and fabricated transistorized sensitive gamma monitor using a 4-inch-by-5-inch NaI detector. Further experimental work is needed to reduce temperature effects on the addenda circuitry to permit operation over the same range as the original detector, amplifier, and count-rate meter (-10°F to +130°F).

Magnetic induction methods are being studied and experimented with to determine feasibility for radiological data and voice communication transfer to and from central stations and personnel dosimeter monitors carried by operating personnel. A tunable twin-T filter was devised to reduce induced 60 CPS noise. If feasible under "noise" considerations on the plant, the system will be a simple and relatively inexpensive method of such information transfer.

Development work was initiated at the request of Radiation Protection Operation, HLO, concerning the circuitry for the readout, scanning, and control portions of an automatic dosimeter-film densitometer instrument which was originally planned by RPO. Portions of the unit are completed; however, several involved circuitry problems remain to be solved to complete the project.

Several large-area, bi-planar diodes were tested for possible use as scintillation detectors in place of multiplier phototubes. The diodes, which operate at 2700 VDC, were determined to be useless for normal radiation instrument use because of extremely low sensitivity. The diodes, at 2700 VDC, were compared with regular multiplier phototubes at 1000 VDC with use of the same NaI crystal. The phototubes had a 10^5 greater current output under identical gamma dose-rate conditions.

An improved method for experimental fabrication of silicon surface barrier diodes has been obtained. Sixteen new diodes were fabricated from 400 ohm-cm silicon and all exhibited a much better back-to-forward resistance ratio than was obtained in previous sample runs. Twenty-five more wafers have been cut, using the new diamond saw, from the 1100 ohm-cm silicon ingot. The same finishing methods will be used. An exceedingly small transistorized alpha monitor was partly completed using high density assembly techniques. This unit uses the silicon diode detectors, a transistor amplifier, a three-kilocycle-per-second oscillator, an 80-millisecond gate, and a resonant (3 Kc/s) air column "speaker". Breadboard tests have been quite satisfactory. The resonant column "speaker" occupies only 0.75 cubic inch and can readily be heard under high ambient noise conditions. Total power (dc) required for the complete circuit is only 36 milliwatts. Experiments continued on Li^6 deposition methods onto the silicon diode faces to permit their use as neutron detectors.

A further study was completed, and a report issued, concerning possible measurement of k_{eff} for subcritical metal assemblies and liquid slurries at HAPO. The study was concerned with the possible use of alpha and gamma activated "pulsed" neutron sources. The procedures considered were those of rapidly rotating a piece of beryllium or other target material past an alpha source or through a collimated beam of photons. The calculations seemed to indicate that neutron yield per unit time from such a method will be a factor of 10^4 to 10^6 lower than for typical commercial pulsed-neutron (tube) generators.

Experimental prototype fabrication continued on a beta-gamma combined area monitor, hand and shoe counter employing background suppression, and cabled-connected clothing and object probes. The unit will be termed a Check-Out Station Monitor and is all transistorized. Fabrication also continues on two experimental scintillation transistorized portable dose-rate meters (0-1 mr/hr full scale first range).

WASHINGTON DESIGNATED PROGRAM

Isotopic Analysis

The mass spectrometer for this program was used exclusively to process program samples during the past month. The performance of the spectrometer continued to be very good and this fact, coupled with the type of samples being processed, allowed the achievement of a sample load far in excess of the normally expected sample load. A new series of isotopic standards were processed during the month, and the results of these analyses are being assembled for a separate report.

TEST REACTOR OPERATIONS

Operation of the PCTR continued routinely during the month with one unscheduled shutdown due to electronic failure.

The NPR reduced water density experiment and the second NPR $\frac{1}{p}\frac{dp}{dT}$ experiment were completed during the month.

The inspection and maintenance program for the control rod drives was continued. Two rod drives were reconditioned leaving two to be completed.

A series of tests was started to determine safe loading patterns for the new fuel channels recently drilled into the PCTR.

Critical loadings, worth measurements of driver fuel, control rods and safety disks and neutron lifetime measurements all with graphite and uranium lattice core loadings will be made.

Critical loadings of 73, 46, and 22 drivers were determined for the three outer groups of fuel holes with a graphite core. A preliminary value of the neutron lifetime for the 46 driver rod configuration is 2.00×10^{-3} seconds.

CUSTOMER WORK

Weather Forecasting and Meteorology Service

Meteorological Services, viz., weather forecasts, observations and climatological services, were provided to plant operations and management personnel on a routine basis. The annual climatological summary for 1960 was completed and the normals, means and extremes for the period 1912-1960 computed.

Type of Forecast	Number Made	% Reliability
8-Hour Production	93	84.2
24-Hour General	62	90.2
Special	130	94.6

January was considerably warmer and drier than usual. All except .05 inch of the 0.33-inch precipitation total occurred during the last 3 days.

Instrumentation and Systems Studies

Fabrication was continued on an alpha-beta-gamma air stack monitor for use in the 325 Building by the Chemical Research Operation, HLO, and on an experimental beta-gamma (mixed fission product) air monitor for use in the 327 Building. This second unit will incorporate a moving-tape filter head.

Estimates were prepared and sent to the Biology Operation, HLO, concerning a special multi-detector head, wide application, radionuclide monitor and analyzer. This unit will, if desired, incorporate some commercial sections. A second instrument was also estimated, using our previously developed transistor (standardized) circuits, for use as a very sensitive portable beta-gamma "field use" monitor.

Fabrication was continued on two alpha "Wand" transistorized monitor units, employing silicon surface barrier diode detectors, for use at the 234-5 Building.

Advice and assistance were given to instrument maintenance personnel concerning the transistorized scintillation beta-gamma shoe and clothing monitor used in the 325-A Building. Sketch-type electro-mechanical drawings were prepared. This unit uses the new lucite wedge light-pipe beta-gamma shoe probes using a 6655-A phototube and a 5-inch-by-14-inch-by-1/16-inch-thick terphenyl-in-polyvinyltoluene scintillator. Such probes can easily detect C^{14} and S^{35} betas and have a uniform beta response over the 5-by-14-inch effective area (for each shoe).

Modification design work continued to provide selectable time constants and hence meter and chart recorder response times for the sensitive transistorized scintillation gamma monitor for Regional Monitoring Operation, HLO.

Design and fabrication requirement details were given to instrument personnel from the 308 Building to permit them to fabricate one vertically-mounted scintillation alpha shoe monitor using a standard 5-by-14-inch wedge-shaped lucite light pipe, phototube, and ZnS phosphor. Detection levels of 500 d/m Pu^{239} should be obtainable. All circuitry employed will be our "standardized" transistor types.

The mechanical mockup portion of the experimental, prototype Laundry Monitor System was successfully demonstrated to interested personnel from the Laundry Operation. The mechanical system is of the continuous movement conveyor type which, by mechanical means, automatically turns the hanger-held coveralls and lab coats to provide monitoring for alpha, beta, and gamma contamination of the complete garment. The problem is obviously one of a complex nature for alpha monitoring. Banks of phototubes with large area (1 foot by 1 foot) lucite light-pipes will be used for the monitoring. ZnS phosphor and terphenyl-in-polyvinyltoluene will be used for alpha and beta-gamma monitoring, respectively. Many of the necessary electronic and detector circuits have already been developed and tested for use with the mechanical portion. If contamination is detected above the pre-set required levels, the control portion of the instrument will cause the particular garment to be dropped, using an electromagnet device, into a "contaminated" hamper for rewashing. Background reduction and cancellation techniques will be employed in the beta-gamma portion because of varying background conditions at the Laundry building. All detectors will be of the scintillation type and all circuitry will be transistorized for maximum reliability.

Consultation was given Fuels Development Operation regarding specifications and proposals for a data logging system for ETR loops.

Work on a chemical dissolver problem has been started for the Chemical Research and Development Operation. This problem concerns the characteristics of a recirculating, plug-flow dissolver and reservoir system.

The new PACE TR-10 analog computer purchased by IPD has been received and checked against specifications by Systems Research. A defective electronic multiplier and comparator were discovered. These components are being replaced by the vendor.

Two peak integrators were recently installed in the X-ray diffraction instruments used by Manufacturing Operation, FPD. The automatic printing feature on the integrators proved to be far too sensitive. Difficulty was encountered in attempting to decrease the sensitivity of the mechanical portion of this device. It was decided to operate the printer from the scanning motor tab switch on the X-ray goniometer table. This would permit the printer to print at the beginning and the end of each peak. A modified time delay relay was installed to actuate the printing mechanism when the scanning switch closed at the start of a peak and opened at the end of the peak.

Development has been started on a hydrogen detection system for the NPR fuel element autoclaves in the 333 Building. When operating, the autoclaves will give off a small amount of hydrogen. After rupture, the hydrogen generated should increase about five times within one-half hour. The proposed gas detection system will monitor the percent of the lower-explosive-limit of a mixture of the hydrogen sample and a fixed air flow. At the request of the project engineers, a test was set up on an autoclave in the 306 Building. Neither the autoclave, the autoclave loading, nor the hydrogen instrument are identical to the final instrument and as such, results will show only a general indication of the instrument operation. Specifications have been written on the eight-point hydrogen system that will be installed in the 333 Building.

Fabrication of the nickel plate process, previously analyzed on the analog computer, has been completed. As predicted, the process was very easy to control. Excessive pump hysteresis may prevent using full controller gain but should cause no difficulty.

The report on the Chemical Engineering Development problem involving temperature distributions through a waste burial cask has been written. This involved a proposed tube-in-tube storage cask capable of positive cooling, both internally and externally, for disposal of highly radioactive waste. It was felt that, due to the extreme rate of heat generation possible, a serious hazard may arise should a bubble form in the annulus containing the waste. Such a void would cause a loss of conductive path to the cooling fluid, and dangerous temperatures could arise in the vicinity of the bubble. Since a certain amount of material is displaced by the bubble, the heat flow paths are distorted from purely radial "flow tubes" to some unknown geometry in two dimensions. The usual method of solution of such a problem is to rewrite the descriptive equation in finite difference form in the space dimension(s). However, the presence of an insulating discontinuity magnified the difficulty of deriving a finite difference equation many times, so recourse was made to the basic analogy between temperature and electrical potential. A relaxation network of mesh points was set up with resistances of appropriate magnitude connecting the nodes. Using Kirchoff's laws, an energy balance was run on all nodes, yielding a set of equations describing the potential at any one point in terms of the surrounding points and the rate of heat generation. These equations were solved simultaneously on an analog computer; the presence of heat generation precluded the use of a simple, passive resistance network. The results were entirely satisfactory and indicated no particular danger, even with a rather large bubble present.

The reference system for calibrating various micro-displacement readout systems was itself calibrated during January, 1961. The readout systems, which are to be calibrated, are intended for Physical Metallurgy Group use in making in-reactor creep measurements. The reference system was found to have the required 0.05 percent accuracy over the range of 0.004 to 1.00 inch, but calibration of the 0.000 to 0.004 inch range (when the required accuracy is ± micro-inches) indicated errors exceeding the required accuracy. In this region, however, the accuracy of the calibrating instrument is somewhat questionable, and the problem of selecting a true reference becomes significant. The questionable data will be further correlated by the Mathematical Analysis Group for the purpose of obtaining some useful assurance and probability factors. Drift tests on the Schaevitz DRS-100 readout system are in progress at the rate of one scale at one temperature per day. Displacement calibrations will begin late in February.

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Optics

Design drawings covering a periscope to be used at 105-C Fuel Examination Facilities for measuring the length of irradiated fuel elements have been completed and approved. Fabrication of the unit will take place in the IPD Machine Shops.

A housing, condensing lens system, and microscope adapter have been designed for Ceramic Fuels Development Operation. The equipment will permit vertical illumination of objects viewed through their long working distance microscope. The high pressure mercury vapor lamp used in this unit provides one of the most compact, high intensity sources of light available. A special microscope eyepiece adapter is being designed to permit simultaneous viewing, photography, and monitoring of light level.

Fabrication of the corner radius viewing microscope for Finished Products, CPD, was completed. The unit was demonstrated and is now being tested by CPD. The difference between a 0.009-inch radius and a 0.003-inch radius in the bottom of an internal groove was clearly seen. Quantitative measurements do not seem possible at this time.

Radiation Ratio Pyrometers for both Physical Metallurgy and FPD have been delivered. The Physical Metallurgy unit has been installed and calibrated. A series of tests of the FPD pyrometer were made using an induction heated zirconium clad uranium piece as the hot object. Comparisons were made between thermocouple readings, radiometer readings (using the radiometer made for FPD by the Optical Shop) and the readings of the radiation ratio pyrometer. The analysis of these data is not complete but with only a few exceptions the radiation ratio pyrometer agrees (after initial calibration) within ± 10 degrees with the thermocouples. Preliminary analysis of the data indicates the thermocouples shift in indication with cycling. When ratio pyrometer readings and thermocouple readings are compared for three specimens in the same cycle, there is agreement within ± 3 degrees.

The calibration curve as given by runs on the zirconium clad specimen differs appreciably from that obtained with the Radiation Standard as a source. As an example, the temperature indicated by the ratio pyrometer when the thermocouple reads 700°C is 770°C. This suggests the emissivity of zirconium is decreasing rapidly with wavelength in the 2- to 3-micron wavelength range. It is also possible the zirconium surface viewed by the Ratio Pyrometer is actually hotter than the point 0.020 inch or more below the surface to which the thermocouple is attached.

There is one very good temperature check point, the thermal rest region, where a phase transformation takes place at a thermocouple reading of 640°C. Here the Ratio Pyrometer reads 693 ± 4°C according to its radiation standard calibration. The ± 4° is the standard error of estimate for seven readings.

A total of 456 manhours' work was performed during the four-week period (January 1 to January 29) included in this report. Of this, 6% was for an offsite order code 0777, 19% for code 1500, 15% for IPD, 19% for CPD, 39% for HLO, and 3% for code 9215.

The work included:

1. Fabrication of four quartz lenses and mounts.
2. Fabrication of ratio pyrometer components.
3. Repair of Lenox 1-1/8-inch-diameter borescope.
4. Fabrication of Corner Radius Viewing Microscope for CPD.
5. Modifications of ultrasonic thickness probe.
6. Repolishing one lead glass viewing window.
7. Evaporation of gold to form silicon diodes.
8. Repair of two crane periscope heads for Purex.
9. Repair of two camera tripods for Photography Unit.
10. Resurfacing pump seals.
11. Cleaning of one microscope.
12. Fabrication of three radiation pyrometers.

Analog Computer Facility Operation

The major analog computer problems considered this month include:

1. NPR primary loop study.
2. NPR secondary loop study.
3. NPR pressurizer study.
4. PRTR critical facility study.
5. Chemical dissolver study.
6. PACE TR-10 (analog computer) evaluation.
7. Waste burial cask--two-dimensional temperature distribution.

Computer Operation:

GEDA		EASE	
135	hours up	136	hours up
33	hours scheduled downtime	12	hours scheduled downtime
0	hours unscheduled downtime	0	hours unscheduled downtime
0	hours idle	20	hours idle
168	hours total	168	hours total

Instrument Evaluation

A complete calibration procedure was written for use with the scintillation (0-200 mr/hr, linear) 614 Building Monitors fabricated for Radiation Monitoring Operation, HLO. By high voltage adjustment, these units can be adjusted to provide any single "range" desired from about 0-30 mr/hr to 0-10 r/hr.

Evaluation tests were completed and reports were written concerning three representative commercial "area monitors" of similar costs. The three instruments were the Keithley 412 Log Electrometer (using a HAPO HM Chamber), a Tracerlab Log Response unit using a lead-shield compensated GM tube detector, and a Nuclear Measurements Corporation (Quasi-log) "Gammaguard" unit using a NaI and phototube detector. All three units had shortcomings for use as HAPO area monitors, and none was satisfactory for continuous-use application under the widely varied conditions required for HAPO area monitors. Complete test details can be found in the issued evaluation reports.

Acceptance tests are nearly complete on 30 new cast-plastic head scintillation alpha probes with effective detection areas of 2 x 7 inches. These developed probes have a uniform geometry, with a 50 percent open-area pierced metal protective screen in place, of about 14 percent, ± 3 percent. These units have no increase in background, from a normal one c/m, in a 4- to 5-r/hr gamma field.

One Model II Scintran prototype is being modified with the addition of three transistor binaries and a GM tube input for selective use as either a scintillation probe alpha monitor (no binaries used) or a GM tube beta-gamma monitor with the binaries. In addition, a 1000 V BF_3 tube can be directly applied to the scintillation input for neutron monitoring or any neutron, alpha, or beta-gamma scintillation probe can be used as desired.

Continued laboratory tests are being conducted on the scintillation transistorized combined alpha-beta-gamma hand and shoe counter before returning it to the field for use. Cross-coupling the four hand probes (two "palm" and two "back") reduces the chance of coincident (both probe) beta-gamma-caused pulses adding to appear as an alpha pulse in the alpha channel. Such cross coupling should improve the alpha signal-to-background ratio to permit easier detection of 200 to 400 d/m Pu^{239} sources. Thus, one register will indicate "counts" from both hand-back probes simultaneously with a similar condition for hand-palm probes. Such a method, however, may meet with opposition from field personnel who are used to the older method of presentation.

Six of twelve ordered "Sentinel" beta-gamma portable scintillation selectable-level alarming dose-rate meters were received from an offsite manufacturer who fabricated them using our circuits throughout. The originally required ranges were 0-1 r/hr and 0-10 r/hr; however, they are not calibrated to give ranges of 0-400 mr/hr and 0-4 r/hr. Operation of the six units, as received, was reasonably satisfactory; however, slight changes in high voltage regulator types and the phototube voltage divider may be in order to permit reliable operation throughout the approximate 100-hour battery life. The operation would be completely satisfactory for the designed (original requirement) two ranges of 0-1 r/hr and 0-10 r/hr. The "change in requirements" to the operation levels of 0-400 mr/hr and 0-4 r/hr with no circuitry changes results in operation of the miniature high voltage supply at a peak level. Slight circuit changes should alleviate the minor problem and permit the proper operation at the new desired levels.

Advice and assistance was rendered to Calibrations Operation, RPO, in revising purchase specifications for self-reading pencil dosimeters. Both 0-50 r/hr and 0-200 mr/hr units are to be purchased. A number of modified 0-5000 r/hr T-P instruments are also to be ordered.

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CHEMICAL RESEARCH AND DEVELOPMENT OPERATION

RESEARCH AND ENGINEERING

FISSIONABLE MATERIALS - 2000 PROGRAM

IRRADIATION PROCESSES

Uranium Oxidation and Fission Product Volatilization Studies

Two fission product release experiments were performed on uranium irradiated to 1.2×10^{20} nvt. In one of these, a helium atmosphere was employed during heating. Rare gas release was 87 percent, less than the 99.5 percent release obtained in an air atmosphere but much greater than that obtained in trace level experiments.

In the other experiment, an air atmosphere was used during which many particles were released from the specimen. A large fraction of the particles penetrated two liquid caustic scrubbers and were deposited on a millipore filter. This corroborated previous observations that showed a greater release of particles from more highly irradiated uranium. As expected, the ratio of uranium to individual fission products in the particles more closely approximated the ratio in the original specimen for the non-volatile elements (Zr, Ru, Np) than for the volatile elements (I, Te, Cs). It was established that particles formed during the oxidation of unirradiated uranium in air over a temperature range of 450 - 1300 C are U_3O_8.

NPR Effluents

Research was continued to seek methods of removing radioisotopes from phosphoric acid decontaminating solution proposed for clean-up of certain portions of the NPR loop. Treatment methods were compared with regard to degree of removal of radioisotopes, amount of caustic required, and amount of sludge produced. The scavenging with precipitates formed by the addition of aluminum sulfate and calcium chloride was compared with that obtained with precipitates formed by the addition of ferrous sulfate and potassium permanganate. The aluminum-calcium process required only about two-thirds as much caustic as did the iron-permanganate process but produced about three times the sludge volume. Both processes satisfactorily scavenged isotopes of cobalt, ruthenium, silver, chromium, zinc, strontium, iron and cerium. Neither was able to appreciably scavenge isotopes of antimony or cesium. Experiments involving the addition of aluminum without calcium gave bulky, gelatinous aluminum hydroxide sludge, more difficult to handle than the more compact crandallite ($CaAl_3(PO_4)_2(OH)_5 \cdot H_2O$) formed when calcium is included. The scavenging effectiveness of aluminum hydroxide appears nearly comparable to that of the other processes although some of the results were anomalous.

Wells 699-67-51 and 699-69-45, the last two on well drilling project CAH-885, were begun. These wells were planned to provide necessary ground water altitudes about a mile and a half north of Gable Mountain where the data may indicate the feasibility of disposal of limited volumes of reactor area wastes to the ground. This disposal would depend on movement of ground waters there into the Columbia River downstream from the intakes of all reactors.

Reactor Effluent Treatment

Preliminary equilibrium experiments to test the adsorption of radioisotopes from reactor effluent by 26 species of minerals were completed. The equilibrium adsorption of P-32, As-76, Np-237, Zn-65 and Cr-51 was determined for each mineral. On the basis of the results ten of the minerals were selected for further study in column experiments. These minerals are olivine, pyrite, pyrrhotite, fluorite, calcite, galena, dolomite, hornblende, scapolite, and geothite. Column experiments to study the adsorption of P-32 were performed with the first five of these. The experiments were performed at relatively fast flow rates (5.7 - 6.7 gal/min/ft^2) giving short residence times (0.5 - 0.7 minutes) in the 50 gram mineral beds. Under these conditions the adsorption capacities of these five minerals appeared to be in the order: pyrite (1050 bed volumes), pyrrhotite (560 bed volumes), fluorite (354 bed volumes), calcite (177 bed volumes), and olivine (106 bed volumes). These columns produced rather erratic breakthrough data, probably as a result of the high flow rates.

Operation of aluminum-filled columns at 100-B and 100-C was terminated, since the production tests to measure the effectiveness of increased alum and the use of aluminum nitrate were completed. Similar columns were installed at 105 C to determine the effect of reduced dichromate ion on aluminum bed decontamination factors. The pilot-scale test facility was operated at six linear feet per minute during the month, with a slight increase in pressure drop noted.

Columbia River Radioisotope Reduction Studies

In the recent test at H reactor, 20 ppm $Al(NO_3)_3 \cdot 9H_2O$ and nitric acid to adjust the pH were used in place of the few parts per million alum and sulfuric acid normally used in treating the process water. Higher purity water was produced which contained reduced amounts of some of the trace elements which are parent materials for the radioisotopes produced in the cooling water. A reduction in amount of radioisotopes formed was also accomplished which, except in the case of Np-239, exceeded the reduction obtained in the parent material. The results for some of the radioisotopes of interest are shown in the table.

Parent Element	Radioactive Daughter	Percent Parent Element Reduction	Percent Radioisotope Reduction
S	P-32	37	70*
P	P-32	11	70*
As	As-76	61	75
U	Np-239	72	57
Zn	Zn-65	0	33

* Combined radioisotope reduction from S and P parents.

These results show that processes other than parent isotope reduction are effective in reducing radioisotopes formed in the cooling water. The effect of reducing other salts in the water and the effect of changes in the reactor tube film are being studied.

SEPARATION PROCESSES

Evaluation of Alternate Diluents for Purex

Adakane-12 and Pacific Base Oil C were tested as diluents for Purex Process solvent. On the basis of resistance to nitration and of fission product distribution, the Adakane-12 (which approaches pure dodecane in composition) was superior to other diluents which have been tested so far. Results obtained with the Pacific Base Oil C were similar to those previously obtained with Shell E-2342.

Recuplex Continuous Dissolver

Cold pilot plant Recuplex continuous dissolver studies were completed with the demonstration of an effective solids trap and dissolution of calcium metal in excess of flowsheet quantities.

A ten-liter baffled solids trap prevented particulate carryover to the product tank. The solids, mostly gelatinous, which collected in the trap were 0.73 w/o of the solids charged during the run. Although the product tank solution appeared to be clear, suspended gels plugged filter paper, diatomacious earth and carbon filter aids, preventing filtration of the product.

No difference in dissolution characteristics was noted when 120 g or 60 g of calcium metal was blended into the cold simulated, solid feed. On the other hand, when 60 g of calcium was added alone (i.e., without other solids) the reaction was violent. Addition of 120 g alone blew manometers and pressurized the system.

The heat of reaction for the cold feed was measured at -1100 kcal/kg in the pilot plant, which compares favorably to the -1040 kcal/kg calculated.

Non-condensable species in the off-gas resulting from the reaction were 50 percent N_2O and 50 percent H_2. The maximum non-condensable off-gas evolution rate is about 2 scfm.

Observation Wells

The southward movement of contaminated ground water originating under the 216-BY scavenged cribsite in 200 East Area continued this month. This is evidenced by increased concentrations of radiocontaminants in monitoring wells north and west of the Purex Plant. The present indicated rate of movement, 30 - 50 feet a day, is appreciably greater than the movement rates evident when the contaminants were in aquifers under the northern part of 200 East Area. The increased rate and direction of movement were as expected based primarily on Purex Plant waste disposal monitoring experience. No long lived radioisotopes, other than low concentrations of Co-60 near the BY cribsite, are detectable in the ground water under 200 East Area.

Waste Tank Leak Field Investigations

Radioisotope analyses of the drilling samples obtained from the five shallow wells recently drilled around the 106-TY tank were completed. The three wells toward the southeast showed the highest concentration of Ru-106 and Cs-137 between the 45 and 65 foot levels. The well northeast of the tank contained relatively high concentrations of Cs-137 but very little Ru-106 throughout its depth which indicates some waste source other than the 106-TY tank, possibly the 105-TY tank or a failed

underground waste transfer line. The maximum Cs-137 detected in this well was 4×10^{-6} uc/gram of soil at 15 feet above the level of the tank bottom. The wells were also monitored with a gamma scintillation probe. Good correlations of the soil sample analytical results and probe readings were obtained.

Disposal to Ground

Further laboratory experiments were made to study the recovery of plutonium from D-6 sump waste from the 234-5 Building. The adsorption medium found to give the best decontamination of this waste was Florida pebble phosphate, a commercially available natural mineral. Columns of this material received D-6 sump waste (pH 2.8) at 1.04 gal/ft^2/min and with a column residence time of 1.36 minutes. More than 90 percent of the plutonium was removed from about 400 column volumes of waste. These columns were eluted with 1.0 M sodium carbonate solution and over 95 percent of the adsorbed plutonium was recovered in 5 bed volumes of eluate. This elution converted part of the phosphate mineral to calcite and therefore it was necessary to recharge the bed before the second adsorption cycle. After recharging with 8 bed volumes of 0.1 M Na_2HPO_4, the column was again used to remove plutonium from D-6 sump waste and was found to have slightly better adsorption characteristics than during the first cycle.

Particulate Sampling and Measurement

Principles relating to particle retention on sampling lines were used to predict the performance of particle sampling probes and lines in a chemical process air stream before and after a new filter installation. Changes in the design were recommended as a result of the analysis.

WASTE TREATMENT

Underground Waste Storage Tank Cleanout

Mining studies for process waste tank cleanout continued with tests of a rotating-head, self-propelling sewer nozzle. The nozzle successfully tunnelled through sand and gravel beds, discharging about 350 gal/min of water under about 125 lb/sq.in. pressure. During operation the free end of the hose was stable (no "whipping") and the nozzle pulled the hose forward in a nearly straight, downward direction. These results suggest that the nozzle could be used to mine tanks, although problems of hose material and directional control remain to be solved.

Batch Calcination

Three bench-scale runs were made on the batch calcination of simulated Purex high-level wastes to study calcine melting. The acidic waste solutions contained only sodium, iron and aluminum sulfates and nitrates. The studies have indicated that the absence of the minor constituents (chromium, nickel, lead, phosphate, acetate, silicon dioxide and manganese dioxide) produces a meltable calcine at higher sodium to metal ion ratios than previously noted with the minor elements present. A melt also formed at a high sulfate to salt nitrate ratio (8.9) with the sodium to metal ion ratio of 1.9.

In two of the runs, the sulfate concentration was greater than the sodium stoichiometric equivalent. The weights of the calcines produced were 30 percent higher than that predicted assuming only sodium sulfate, ferric oxide and aluminum oxide are

present. Both calcines melted and were held at temperatures in excess of 900 C until the evolution of sulfur oxides was no longer evident.

Calcine Storage Problems

Studies of self-heating of calcined high-level wastes stored in annuli are continuing. The effect upon the maximum temperature within the calciner of a void inclusion near the outer periphery has been estimated for a typical case by analog computation. It appears that the commonly observed types of void inclusions will not significantly increase the maximum internal temperatures within the stored wastes.

TRANSURANIC ELEMENT AND FISSION PRODUCT RECOVERY

Strontium Recovery Program

325-A Strontium Purification Runs - The first full-level strontium-90 purification run in the A-Cell ion-exchange equipment (initiated in December) was successfully completed, as was a second run. Some 5100 curies of purified strontium-90 was recovered in the first run and stored in the product tanks, pending shipment. An additional 1500 curies of partially purified material is being held for re-work. Eight thousand three hundred and fifty (8350) curies of purified product was obtained in the second run, bringing the total inventory of purified strontium-90 to 13,450 curies. Isotopic purity of the product was 56.0 ± 0.2 percent strontium-90, very close to theoretical. Chemical and radiochemical purity was also very satisfactory. The product of the first run analyzed 76.1 weight percent strontium, 11.0 percent calcium, 12.1 percent copper, and < 0.8 percent barium. Data on the second run are not complete, but copper was eliminated through a process change and other impurities are also expected to have been substantially reduced. No radioactivity, other than that due to strontium (and its yttrium daughter), could be detected in either product. Although both mechanical and flowsheet operation was very satisfactory during the two runs, several minor equipment failures (leaking gaskets and valves) necessitate decontamination and repair prior to the next run. Highlights of process changes and significant observations are described in the following paragraphs.

As mentioned last month, the as-received F-8 strontium concentrate contained copious quantities of solids which required addition of one mole of nitric acid per liter of solution to effect feed clarification. Solids in the feed used in the second run were even more refractory. Addition of 1.6 moles of acid per liter failed to completely dissolve them, and the acidified feed could not be filtered through a coarse sintered stainless steel filter. However, the remaining solids in the acidified (and HEDTA complexed) feed did not appear to clog the ion-exchange columns. In both runs, an excess of HEDTA (over that required to complex iron and lead) was added and the pH adjusted to a value of 4.0 (by ammonia addition) prior to feeding to the columns. This treatment proved very effective in preventing absorption of cerium, other rare earths, and zirconium-niobium (as well as iron and lead). The only exception was a brief period during the loading cycle of run number 2 when an insufficient quantity of HEDTA was inadvertently used. Some 25,000 curies of cerium loaded before this condition was detected and there was evidence of damage to the resin (dark color and increased pressure drop). A wash with a pH 4 HEDTA solution was successful in removing most of the absorbed cerium, and loading was continued after butting with additional HEDTA.

Capacity of the installed equipment was expected, on the basis of cold runs, to be well in excess of 15,000 curies of strontium-90 per run. That found in the two hot

runs was substantially lower, a situation which may be due either to the large amount of acid required to clarify the feed (which results in a high ammonium ion concentration) or to some unknown impurity in the Purex material (which would tend to saturate ion exchange sites). Breakthrough in the first run occurred unexpectedly at 7200 curies (despite use of two columns) and resulted in an overall recovery of only about 40 percent. The volume of feed used in the second run was tailored to the empirical capacity, resulting in an overall recovery, from feed to purified product, in excess of 90 percent. Small ion exchange columns are being installed in B-Cell to study, with small volumes of feed, ways of increasing the capacity of the process.

In the first hot run, the purification columns were in the mixed copper-hydrogen cycle, as had been the case in the cold runs and in previous (cold) promethium purification experiments. The copper serves as restraining ion, to keep the leading-edge sharp, and any cerium and yttrium that may be present collect behind the copper (because of the relative EDTA complexing constants) and cause a very high radiation intensity at that point. This intense, localized radiation caused severe gassing and also reduction of some of the cupric ion to metallic copper, an unexpected observation which was subsequently duplicated in the cobalt source. Both phenomena (gassing and plugging with copper), caused channeling and band tilting. Although the process was still operable, purification was undoubtedly impaired, and the metallic copper caused severe gassing and contributed copper impurity when the product was finally stripped from the last column with nitric acid. To eliminate these difficulties, calcium was used as restraining ion in the second run and proved very satisfactory. Yttrium (which forms continuously from strontium decay) and any residual cerium passed continuously from the calcium form column, the bands were very well defined, and gassing was negligible. Copper was still used as restraining ion on the final isolation column; however, the copper was stripped off with acidic HEDTA (which does not displace strontium) as soon as the strontium band had moved onto the column and prior to eluting the strontium with nitric acid. Although this worked satisfactorily, "cold" cerium will probably be used as restraining ion on this column in future runs to completely eliminate the possibility of metallic copper formation. Cerium, like copper, can be removed with acidic HEDTA prior to strontium elution.

The two runs afforded a thorough test of both the in-cell gamma spectrometer and the in-cell ionization chamber -- which is installed at the bottom of column number 5 to monitor passage of the strontium band. Both instruments performed satisfactorily and proved invaluable to operation of the process. A similar ionization chamber "strontium detector" is accordingly planned for installation at the Hot Semiworks. During the runs it was also discovered that self-luminous bands, which were observed in the glass columns when the lights were turned out, were due to the strontium and cerium-yttrium. These luminous bands proved very useful in controlling the operation.

Hot Semiworks Strontium-90 Recovery Program

Feed Make-Up for Solvent Extraction - Synthetic feed solutions (IAF) were subjected to gamma irradiation. In these tests, solids formation began at exposures about 1×10^8 R; at 2.6×10^8 R solids volume was still less than 0.1 volume percent. However, these solids carried significant amounts of strontium. Based on an estima' exposure level of 1.3×10^6 R/hr in Hot Semiworks feeds, solids formation should not occur in less than two days. Feed solutions will normally be processed in less than 12 hours. Strontium carried on the solids was resolubilized by acidifying the slurries to a pH about 1.5.

Laboratory Solvent Extraction Studies - Further mini runs simulating 1A Column extraction conditions were made (first study flowsheet). Calcium extracted almost completely under these conditions; the cesium decontamination factor was 3×10^4. In one run a solvent previously irradiated to 2×10^7 R was used; strontium recovery and decontamination were not adversely affected. In another run irradiated solvent not given the usual pretreatment (washing with 10 percent NaOH and 6 M HNO_3) was used; again strontium recovery and decontamination were not adversely affected.

Batch contact studies indicate that molybdenum, if present in crude cut solution as molybdate species, will not extract significantly under proposed 1A Column conditions. The effect of ethylenediamine tetracetic acid (EDTA) concentration on extraction of crude cut constituents under 1A Column conditions was studied in detail. As expected, extraction of all constituents decreased with increasing EDTA concentrations.

Miniature pulse column runs were made to test variations in the 1B Column partitioning flowsheet. Chloroacetic, dichloroacetic and maleic acids were tested as alternates for citric acid in the aqueous phase. Dichloroacetic acid is a better buffering agent and produced a higher strontium-cerium separation factor than any other reagent yet tested in the 1B Column. Two molar acetic acid (vice one molar) was tested using synthetic 1AP solution as feed to the 1B Column. Over 99 percent of the strontium was stripped from the organic; strontium-cerium and strontium-calcium separation factors were over thirty.

Installation and testing of equipment in the 222-S cubicle is essentially complete. It is expected that miniature mixer settler runs using full level Purex crude cut solution will start early in February.

Pilot Plant Strontium Solvent Extraction Studies - A second study flowsheet for the recovery of strontium from Purex crude cut solution by solvent-extraction has been prepared and is currently being tested in cold semiworks pulse columns. This flowsheet has the following features:

1. The feed is prepared by complexing the iron, lead, and most of the undesirable fission products with 50 percent excess EDTA and by adjusting the pH to ca. 4.2 with sodium acetate and sodium hydroxide.

2. The feed enters the 1A Column near the midpoint where it is counter-currently contacted with 0.4 M di-2-ethylhexylphosphoric acid (D2EHPA) plus 0.2 M TBP in Shell E-2342 diluent. Under these conditions, all the strontium and calcium and $\leq$10 percent of the cerium should be extracted.

3. A scrub stream containing 0.6 M citric acid neutralized to a pH of 2.6 to 3.0 is introduced at the top of the 1A Column. The purpose of this stream is to remove residual "inextractable" metal ions and to lower the sodium concentration in the organic product stream.

4. The product overflows to the 1B Column where it is countercurrently contacted with 1 M citric acid. The flow ratio is adjusted to permit stripping of essentially all of the strontium while leaving $\geq$75 percent of the calcium and $\geq$95 percent of the cerium and other rare earths in the solvent. The product stream leaving the column at a pH of 2.1 to 2.3 is suitable feed for a cation exchange column (Dowex 50 resin); however, for improved cerium DF, the pH will probably be adjusted to about three.

5. Flow ratios in the above process are tentatively set as follows: IAF:IAS:IAX:IBX = 100:5:25:6. The strontium concentration in the IB product will be about 5 g/l.

Preliminary results of the demonstration runs completed so far indicate that less than three percent of the strontium should be lost in the IA Column and less than five percent in the IB Column. The use of partially neutralized citric acid in the IAS seemed to effectively remove sodium from the solvent. In one run with a pH 4.7 feed and an inefficient-appearing scrub section, the sodium concentration in the solvent was reduced from 3.8 g/l at the feed point to 1.3 g/l in the IA product. A more efficient cartridge has been installed which should reduce the sodium content still further. The pH of the IBP with this improved flowsheet has been reduced from 3.2 to $\leq$2.4 while using a pH 4.7 feed and the above flow ratios. The minimum IBP pH, using a pH 3.8 feed, should be about 2. Over this range of pH (2.0 to 2.4) the Sr E_a^o varies from about 0.09 to 0.3. The Ca E_a^o should be about 20 times the Sr value while the Ce E_a^o should vary from 20 to 50.

Hot Semiworks Reactivation - Progress in the construction program for interim processing of strontium-90 has led to the acceptance of two processing cells, A and C Cell, for functional testing. Construction is 100 percent complete in C Cell, 98 percent complete in A Cell, and 75 percent in B Cell with the overall project being about 85 percent complete. To date functional testing of about 70 percent of the equipment has revealed a relatively good operating condition for most of the equipment.

Major areas of construction have been: (a) two new 4-inch diameter solvent extraction columns, (b) an 8-inch diameter ion exchange column, all welded process piping in A Cell, (c) repiping of existing equipment to fit the process, (d) revamping of the process vent system, additional containment, (e) transport line, (g) loadout facilities, and (h) general reactivation and repair of existing equipment.

Preparation of Solid Strontium Compounds for Shipment - Precipitation of strontium peroxide and decomposition of the peroxide to strontium oxide is being investigated as a means of preparing a relatively stable strontium compound for shipment. The peroxide has been prepared from strontium nitrate, strontium hydroxide and simulated solvent extraction IXP (ion exchange column eluate) solution. Hydrogen peroxide is added along with sufficient sodium hydroxide to keep the solution alkaline. The $SrO_2.8H_2O$ formed was readily filtered on Whatman No. 1 paper. Recovery was essentially complete with 100 percent excess peroxide. Tapped density of powders dried at 105 C was 0.4 g/cc. Preliminary thermal decomposition experiments indicate complete conversion of the peroxide to the oxide in one hour at 400 C. Separation of calcium and strontium in the peroxide precipitation has not been determined. Calcium peroxide is reported to be more soluble than strontium peroxide.

Strontium Peroxide Filtration - Semiworks scale filtration studies have been started on strontium peroxide as an intermediate to the preparation of strontium oxide. Filterability is comparable to strontium carbonate prepared by bicarbonate hydrolysis.

Fission Product Packaging Prototype - Technology is being developed in support of a conceptual Sr-90 packaging system for B Plant. The objective is to define process and equipment requirements to convert strontium nitrate solution to a dry, free-flowing strontium product packaged for offsite shipment. The concept includes a radiant-he spray calciner as the thermal conversion unit. Design of a prototype of the latter unit is approximately 50 percent complete.

In other studies, canister calcination (direct calcination in the shipping container without agitation) of strontium nitrate is being investigated as a means of providing a stable packaged product with maximum simplicity and minimum remote handling. Initial studies appear favorable.

Strontium Shipping Cask - Annular Decalso Unit - Tests of a hydraulic mock-up of the annular inorganic ion exchange bed (+30 mesh Decalso) proposed for Sr-90 shipment were completed with studies of liquid distribution during loading and elution. Optimum solution flow patterns were obtained by prefluidization of a 90 percent full bed to achieve uniform packing followed by downflow loading or elution.

Lead-Stainless Steel Bonds in the Fission Product Transfer Cask - To assure adequate heat transfer in the fission product transfer cask currently in fabrication, it is necessary that the bond between lead and stainless steel in the cask remain intact through thermal cycling. A sample consisting of a stainless steel pipe poured full of lead was obtained from the fabricator. The surface pretreatment and pouring procedures used in preparing the sample were the same as those proposed for cask fabrication. Wafers cut from the lead pipe were exposed at temperatures of 300, 350 and 400 F in argon-filled desiccator. Each sample was subjected to eleven thermal cycles in which the temperature was reduced to 100 F for one hour and then returned to the test temperature. No evidence of separation of the lead-stainless steel bond was noted on any of the samples.

Measurement of Calcium and Cerium in Strontium Recovery Streams

Reliable, rapid measurement of calcium, cerium and barium was needed to follow strontium purification while developing a solvent extraction process for recovering strontium. Despite D2EHPA's (the process extractant) impairing seriously much of the normal calcium and cerium analytical technology, suitably rapid analytical methods were developed for the two metals. The success of each method depended primarily upon increasing the response of the metal sought in order to allow dilution of samples and consequent reduction of interferences from sample matrices. Calcium was analyzed flamephotometrically in sample diluted as much as 200 times with 49.5 percent 2-n-butoxyethanol - 0.5 percent perchloric acid. Both aqueous and organic samples were soluble in the diluent. Calcium emission was enhanced by the butoxyethanol. Preliminary testing of the method indicated a 5 percent error. Determination of cerium was done by the copper spark emission spectrographic method. Its ability to detect 0.02 microgram of cerium permitted reducing matrix interferences by diluting the samples. Some samples, including those of the organic, strontium product stream, contained too little cerium to allow dilution. The error of the method was some 15 percent where sample dilution was possible; otherwise, 50 percent. Modification of the cerium method gave a feasible determination of the less important barium.

Determination of Physical Properties of Low Melting Alloy

The melting points, freezing points, and contraction and expansion on solidification and ageing were determined for low-melting bismuth-lead-tin-cadmium alloys under consideration for heat transfer media in fission product shipping casks. Equipment was devised to measure the volumetric change of the alloy to ± 30 percent during melting, solidification, cooling and ageing. Linear coefficients of expansion of a rapidly chilled bar were measured to ± 10 percent with a dial gauge in a simple, rigid mount. Melting and solidification points were determined by measurement of the rate of temperature change with uniform heat input. The equipment is suitable for alloys that do not react with liquid water.

ANALYTICAL AND INSTRUMENTAL CHEMISTRY

Reliability of Ru-103 Determinations by Beta Absorption Counting

The method of Buschbom and Nicholson (HW-67305) was used to measure the counting error in Ru-103 determinations derived from beta absorption counting of Ru-103 - Ru-106 mixtures. The method included a consideration of the errors introduced by (a) the magnitude of Ru-103/106 counting rates obtained with and without an absorber, (b) the Ru-103 to Ru-106 ratio, (c) the calibrations for each isotope, and (d) the counter backgrounds. Currently, most material has a 103/106 ratio below 0.1 and the error of a Ru-103 result based on one 10-minute count is 100 to 150 percent. By comparison, simplified counting statistics erroneously suggest an error of only 20 percent. As may be expected, error was largely dependent upon the 103/106 ratio and on the sample/background ratio.

EQUIPMENT AND MATERIALS

Magnetic Pulser

Pulse pressures developed in the 1.55-inch totally enclosed magnetic pulser were measured. The peak pressure was varied from 3 to 10 psig by varying the power from minimum to maximum at a pulse frequency of 40 cycles per minute. The pressure quickly reaches a maximum and then goes to zero gradually over the last half of the stroke. The positive and negative pulse had the same characteristics. Performance of this type of pulse has not been determined.

Continuous Centrifuge

The 6-inch continuous centrifuge intended for use in Z Plant has been damaged again by vibration resulting from misalignment during assembly. During the recent visit of the manufacturer's representative (reported last month) the machine was assembled with 0.002-inch TIR (total indicated runout) at the outboard end of the bowl and the machine ran quietly. However, upon reassembly after the machine was taken down for a minor modification, there was 0.004-inch TIR at the end of the bowl. This was considered to be within reasonable limits and the machine was started up. Vibration was noticeable but not excessive until the bowl was filled with water. The vibration then increased to the point where the rotating bowl hit the stationary case. The bowl was deformed so that there is now 0.011-inch TIR at the outboard end. Further work will depend on the recommendations of the manufacturer.

Pump, Agitator, and Valve Development

A total of five Chempumps have now been modified to include tapered bearings and hydroclones, run-in tested, and delivered to the Chemical Processing Department for plant installation.

The HAPO designed and fabricated deepwell turbine pump-agitator for Redox TK-E3 has passed its 100 hour run-in. Head and capacity characteristics were in excess of those required and operation was smooth. The pump-agitator has been transferred to the plant for installation.

Experimental Nickel-Base Alloys

Samples from two small heats of HAPO-20 alloy produced by the General Electric Company, Metallurgical Products Department, have been received. Corrosion rates for the two heats were nearly identical on exposure to HNO_3-HF solutions and to 65 w/o HNO_3 (Huey test) although the melting procedures used in producing the two heats were quite different. Corrosion rates in HNO_3-HF were nearly the same as for a heat of the alloy produced at Battelle Memorial Institute; rates in the Huey test were slightly higher.

Non-Metallic Materials

Two samples of polyethylene which were submitted to the Chemical Processing Department for possible use in Purex pulse columns were tested for radiation damage. Both are linear polyethylene with an additive to improve fabrication characteristics. Neither of the samples is the equivalent of linear polyethylene in radiation stability.

A sample of aluminum silicate was tested in a chlorine saturated sodium-potassium chloride melt at 700 C for four days. There was a small amount of surface checking evident on the sample at the conclusion of the test which may have been caused by thermal shock. The test is being repeated.

PROCESS CONTROL DEVELOPMENT

Electrolytic Conductivity Cell

Calibration of the newly designed electrolytic conductivity cell described last month is now complete. Curves of electrical conductance vs. nitric acid concentration ranging from 1 to 3 molar have been established over the temperature range 25 to 50 C. The precision of the measurements is estimated to be ± 2 percent near one molar acid and ± 4 percent at 3 molar acid.

The cell used for these calibration runs is scheduled to be installed as a prototype on the Purex 1BP sample line downstream from the 1BP neutron monitor. Drawings of piping details are being prepared for installation in the 1BP sampler enclosure.

Calciner Furnace Control System

A K-calciner test in which the calciner furnace temperature controller was used to manually program the finish section shell temperature during startup revealed a system malfunction when the setting of one of the phase balance rheostats (TZ-2) was adjusted downward. The resulting upward excursion of shell temperature was traced to the fact that the feedback voltage to the controller is proportional to the change in rheostat setting in the phase supplying the feedback voltage. To minimize this temperature excursion the feedback phase rheostat, TZ-2, must be set and locked at 20 percent of full scale, and power adjustments to balance the furnace shell temperatures during operation must be made with the other two phase rheostats.

Control System Study for Redox 1B, 2A, and 2B Columns

A proposed control system for Redox 1B, 2A and 2B columns has been reviewed and discussed with CPD Research and Engineering personnel and a Foxboro field engineer.

Sufficient information was obtained to be certain that the necessary analog calculations can be carried out pneumatically by making minor additions and modifications to existing instrumentation. All hardware necessary for cascade and ratio control of the existing Foxboro Model 40 controllers is also available as standard equipment.

Control System Development for Recuplex

A method of modifying the present flow controllers at Recuplex to function as ratio controllers has been investigated. It now appears that this can be accomplished with commercially available equipment at about $200 per controller. The first flow ratio control application to be tested will be the CCF to CCX flow ratio. The optimum operating ratio will be determined by the product concentration in the top of the CC columns as measured with a neutron monitor.

C Column Tests and Facilities

Experimental runs to define the flooding capacity limits were initiated this month. Among other things the flooding threshold was observed to be a function of the degree of interface control. This is related to the dissipation of the pulse energy in the product exit line from the column. The facility was down for part of the month to service the pulse amplitude control device, to install pressure transducers for column density monitors and other miscellaneous services and adjustments.

C Column Data Treatment

Available data on the concentration of nitric acid vs. pH in uranyl nitrate solutions was extracted from the literature and punched into IBM cards. This information will be used in the reduction of the data obtained with the absorptiometer Data Logger, described last month. It was decided that direct measurement of the equilibrated organic acid concentration was not necessary, as it will be determined from the measured values of organic uranium, aqueous uranium, and aqueous acid concentrations. For this purpose tabulated equilibrium organic acid data were obtained from Figure 4, KAPL-602 and punched into IBM cards.

The necessary revisions in the Data Reduction Code were made to accommodate this latest additional means by which data may be obtained.

Analytical Expression for Equilibrium Diagrams

Development of equations to fit the curves of the equilibrium diagram for the system (organic uranium conc. vs. aqueous uranium conc. and aqueous acid) proceeded during the month. The equations determined thus far related organic uranium conc. to aqueous uranium conc. at constant aqueous acid values of 3.0, 2.0, 1.0, 0.03 and 0.00 molar.

The form of these equations was predicted by chemical equlibrium theory. These equations fit the data well for the high acid curves, but with less accuracy for the low acid curves. However, these equations generally contain fractional exponents and are too complex to be useful for substitution into an analytical model of extraction column behavior. Therefore, to obtain a more useable form of equation, the data are being fitted empirically by a polynomial expression. These polynomial equations are currently being developed for the low acid curves, i.e., the operational range of the C Column.

REACTOR DEVELOPMENT - 4000 PROGRAM

PLUTONIUM RECYCLE PROGRAM

Salt Cycle Process

Plutonium Behavior - Additional attempts have been made to segregate the effects of water vapor and oxygen in determining the extent to which plutonium "follows" uranium during electrodeposition of UO_2. Three "co-depositions" were made in the presence of three different sweep gases, as indicated. Results obtained were as follows:

Sweep Gas	Pu/U in Deposit	
	Pu/U in Salt after Partition Deposition	Pu/U in Initial Feed
Dried Air	0.3	0.4
Air containing H_2O Vapor at 4.5 mm Hg	1.0	1.4
Helium containing H_2O Vapor at 23 mm Hg	0.85	1.25

In all three cases, a prior "partition" deposition had been made, under oxygen-free and moisture-free conditions. These gave the expected result, a portion of the uranium being removed as "by-product" UO_2, essentially free of plutonium. Separation factors in these three partition depositions were 100, 150 and 125.

From the tabulated "co-deposition" results, it is apparent that water vapor is a desirable ingredient, and indeed may be the essential one. However, the only case in which plutonium deposited at an equal (relative) rate with uranium was in the experiment in which both oxygen and water vapor were present.

Studies of Electrode Processes in NaCl-KCl System - Recent studies confirm that oxygen and water vapor have distinctly different effects on electrode polarization during electrodeposition of UO_2.

In these experiments, the extent of electrode polarization is evaluated by measuring the limiting current, i.e., the value of current at which the current passed by the electrolysis cell is independent of voltage applied to the cell. The value of the limiting current was first ascertained with a helium sweep after which the effect of a different gas sweep was evaluated.

It was found that dry air has the effect of depolarizing the electrode(s), allowing the limiting current to double. Conversely, a moist air sweep has a distinct polarizing effect, the limiting current decreasing with time, and approaching a value of about one-third that existing with a helium sweep.

The effect of dried air in depolarizing the electrode appears also to be directly related to uranium concentration, i.e., doubling the uranium concentration doubles the limiting current which can be obtained.

These observations suggest a number of speculative possibilities as to pertinent mechanisms. However, additional data will be required to pare these to a manageable number.

Growth of UO_2 Crystals

Attempts to date to over-grow a seed crystal to product a large single crystal of UO_2 via electrodeposition have been largely unsuccessful, owing to an inability to prevent polycrystalline growth. A difficulty appears to be the tendency for polycrystalline growth to initiate at the melt interface when the seed crystal is only partially immersed in the melt.

Some success has been experienced in enlarging certain crystals experimentally by initiating growth on a highly-polarized micro-electrode. Under these conditions certain crystals grow preferentially and the end result is a "mace" composed of long, "spear-shaped" crystallites extending radially in all directions from the initial micro-electrode. X-ray diffraction shows these crystallites to be either single crystals or at most a very small number of similarly oriented single crystals. Crystallites up to 3 mm long have been grown in this fashion and it is hoped that further refinements will enable this growth to be emphasized in a single direction to further enlarge one or a few of the individual crystallites to obtain larger single crystals.

KCl-$PbCl_2$ System - Studies are continuing on the KCl-$PbCl_2$ melt, as a potential lower-melting medium in which to apply the Salt Cycle Process. Interesting aspects of the KCl-$PbCl_2$ system disclosed by recent studies include the following:

1. The physical appearance of UO_2 deposits made by electrodeposition out of 47.3 m/o KCl-52.7 m/o $PbCl_2$ at 450 C is not significantly altered when the gas sweep above the melt is changed from chlorine to helium to dry air to laboratory air (ca. 20 percent relative humidity). The UO_2 deposits in all cases were dendritic in appearance, individual growths being ca. 2 mm in length and 0.2 mm in diameter, and including a high proportion of fines. Likewise, changing the current density from 0.057 to 0.18 amps/cm^2 had no apparent affect on the appearance or tap density of the product. No data are yet available on chemical content or oxygen/uranium ratio.

   This behavior is in marked contrast to that observed in NaCl-KCl at 700 to 800 C. In this system replacing an air environment with a chlorine environment changes the deposit from a porous "dendritic" deposit to a smooth, dense, tightly adherent deposit.

   It is suspected that this difference is largely one of temperature. The inference is that the preferred growth of UO_2 via electrodeposition is as needle-like crystallites but that at 700 to 800 C in the presence of chlorine and uranium(IV) (formed by reaction of UO_2Cl_2 with carbon and chlorine at the graphite anode), the UO_2 deposit is re-dissolved as it forms, the net result being a chemically polished smooth deposit. In the KCl-$PbCl_2$ system both these dissolution processes are suppressed and the UO_2 is allowed to grow in its preferred orientation.

2. The deposition potentials for UO_2 and lead are separated by a sufficiently wide margin to make electrodeposition of UO_2 easily practical out of such melts. For example, the deposition of UO_2 out of 0.15 molal UO_2Cl_2 - 47.3 m/o KCl, 52.7 m/o $PbCl_2$ occurs at a potential about 0.75 volts below that at which lead deposits. This is consistent with the reported high degree of complexing of lead in this melt, in which the lead has been reported to exist primarily as anionic species.

3. A variety of observations suggest that the KCl-$PbCl_2$ system offers the prospect of greater versatility than the NaCl-KCl system in that the effective concentration of "free chloride" can be varied over wider limits, by simply varying the KCl/$PbCl_2$ ratio. Dissolution of UO_2 into KCl-$PbCl_2$ by chlorine is substantially faster than into KCl-$PbCl_2$. Likewise, the deposition potentials for both UO_2 and lead are increased somewhat when the KCl/$PbCl_2$ mole ratio is increased from 1 to 2. Interestingly, electrodeposition of UO_2 out of 2KCl-$PbCl_2$ produced "spear-point" crystals as before but in this case the individual crystals were significantly larger, about 3 mm long by 0.5 mm in diameter. Last, although no chemical analyses are available, the occluded salt appeared to be more readily removed by washing with hot water when the deposition was made out of 2KCl-$PbCl_2$.

Thus, the KCl-$PbCl_2$ systems offer attractive possibilities for uranium processing but any decision as to their utility for the Salt Cycle Process must await planned studies with plutonium.

Chemical Decladding - Studies of the integration of a chemical decladding step into the Salt Cycle Process have continued. A Zircaloy-clad UO_2 fuel pin was declad with molten $PbCl_2$ at 550 C. The zirconium was volatilized as $ZrCl_4$ and condensed in a Pyrex tube. The reaction was essentially complete in 15 minutes, although small amounts of $ZrCl_4$ were still evolving after two hours. At this point KCl was added to form an equimolar KCl-$PbCl_2$ mixture. One mole percent CuCl was added as a catalyst. The solution was chlorinated at 600 C for 150 minutes to dissolve the UO_2. An electrolysis was then carried out at 550 C but no deposit of UO_2 was found on the cathode.

Electrolyses of UO_2Cl_2 in the presence of $ZrCl_4$ dissolved in equimolar KCl-$PbCl_2$ at 550 C preceded by chlorination at 600 C and in equimolar NaCl-KCl at 700 C preceded by chlorination at 800 C gave poor UO_2 deposits. Similar chlorinations and electrolyses of UO_2Cl_2 in both melts in the presence of 0.5 mol percent CuCl, 0.5 mol percent TlCl, or ZrO_2 fines, gave good UO_2 deposits.

Visual observation has indicated that a boiling mixture of dilute acetic acid and EDTA is more effective than boiling water in removing $PbCl_2$ from UO_2 deposits. Chemical analyses of salt samples and UO_2 deposits are not yet available.

Materials of Construction - Chlorinations and electrolyses of UO_2Cl_2 were carried out with both equimolar KCl-$PbCl_2$ and equimolar NaCl-KCl in Hastelloy D crucibles with Hastelloy D cathodes and graphite anodes. Good UO_2 deposits were obtained with little apparent corrosion of the Hastelloy D.

Conversion of UNH to UO_2 - A test was made to determine the feasibility of converting UNH to UO_2 in a molten salt bath. Pieces of solid UNH were added to equimolar $PbCl_2$-KCl at 550-650 C. Fine particles produced appreciable foaming and reacted violently but pieces about half an inch in diameter reacted more slowly and produced very little splashing. All pieces disintegrated rapidly with the production of NO_2 fumes, but an orange deposit was later found on the bottom of the crucible. The solution was chlorinated at 650 C for 140 minutes and electrolyzed but no UO_2 deposit was obtained. After six more hours of chlorination a second electrolysis gave a loosely adherent UO_2 deposit.

Continuous Ion Exchange Contactor Development - Jiggler Contactor

Investigation of the parallel arrangement of the adsorption and elution columns is continuing. The C Column, however, has been modified by replacing three feet of the upper part of the column (which contained liquid) with an air lift recycle line to the A Column. The removal of part of the liquid head creates a hydraulic imbalance which assists in moving the resin. Operational tests are underway to determine whether or not this imbalance will adversely affect the flow of feed and scrub streams. To assist the upward resin movement elution upflow will be used in the C Column.

The physical operation of the present arrangement appears to be the best attained to date. If the hydraulic tests prove favorable, these will be followed by efficiency runs with thorium-traced feeds.

RADIOACTIVE RESIDUE FIXATION

Meltable Mixtures

Results were reported last month on the melting characteristics of certain sodium sulfate-ferric sulfate mixtures which are of interest in waste calcination. Measurements were made this month of the pressures developed above such meltable mixtures in the temperature range 700 to 900 C. Maximum pressure observed was 27 pounds per square inch. Although the longest heating time was only about six hours, these results seem to indicate that excessively high pressures will not be developed during storage.

Radiant Heat Spray Calciner

The spray calciner has been re-assembled with the jack-leg filter, which was designed for in-cell use to reduce overall height, and with ceramic cloth filters in the filter unit. Two runs have been made -- one with a single-fluid high pressure nozzle and the other with a two-fluid nozzle of the type used in most previous runs. The same feed, simulating a projected plant composition, was used in both runs. Both the ceramic cloth filters and the jack-leg arrangement seemed to function very well, although longer runs will be necessary to give a thorough test. The high pressure nozzle gave a powder product that had a larger particle size and was more free-flowing than normal; however, with this nozzle there was considerable impingement on the upper walls of the column (10 to 20 inches below the nozzle). This type of nozzle may, therefore, find application in larger sized units, where less impingement would occur, but two-fluid nozzles continue to be preferred for small columns.

Mineral Reactions

Laboratory studies of the elution of adsorbed cesium from clinoptilolite utilized 2.5 M solutions of ammonium sulfate. This elution was compared with that using 5 M ammonium nitrate. Roughly twice the volume of ammonium sulfate solution was required to attain the same elution. It is desirable to avoid ammonium nitrate as an eluting solution because of the instability of the salt under some conditions. Further experiments will evaluate ammonium acetate as an eluant for cesium. Clinoptilolite columns were also experimentally eluted with 2 M nitric acid since

this eluant would produce a desirable feed for a calcination process. This resulted in very slow cesium elution compared to either ammonium salt. Radiostrontium is rapidly eluted from clinoptilolite by either ammonium nitrate or ammonium sulfate solutions, more than 99 percent being recovered in the first column volume.

Suspended organic material is removed from Purex boiling waste tank condensate by a bed of activated carbon much more effectively at pH 5 than at the normal solution pH 9. The waste initially contains about 100 ppm TBP and about 20 ppm petroleum diluent. The carbon bed does not remove all dissolved organics but the effluent is free of suspended matter. Laboratory experiments indicated a carbon bed capacity at least greater than 1000 bed volumes. The small amount of dissolved organic material is not expected to interfere with the ion exchange of radioisotopes as did the suspended matter.

The reduced pH affects the adsorption of some of the radioisotopes from the waste by clinoptilolite, particularly the adsorption of radiostrontium. It was found that a commercial sulphonated polystyrene resin readily adsorbs both strontium and cesium from these wastes in the pH range 1.6 to 7.1. Strontium equilibrium distribution coefficients greater than 75,000 were obtained with this resin and a 22 cm bed flowing at 4 gal/ft^2/min gave a strontium decontamination factor greater than 1000. This material had cesium equilibrium distribution coefficients ranging from 700 to 2000 in the pH range studied and the 22 cm column also gave a cesium decontamination factor greater than 1000.

Studies of the effect of solution pH on the fixation of radioisotopes from neutralized Purex 1WW waste on beds of zeolites were continued. Experiments were conducted to compare the behavior of clinoptilolite with that of a commercial synthetic zeolite. The equilibrium distribution coefficients for cesium and cerium were measured for each of the zeolites at various pH levels, using synthetic 1WW Purex waste spiked with samples of actual waste. At each pH the measured distribution coefficient with clinoptilolite was higher than that with the synthetic zeolite for both cesium and cerium. Clinoptilolite had cesium distribution coefficients ranging from 950 at pH 1.3 to 1770 at pH 11.8, and cerium distribution coefficients ranging from 1.7 at pH 1.6 to 3640 at pH 11.6.

Condensate Streams

Early experiments in the Micro Pilot Plant (MPP) indicated that removal of organic matter from Purex Tank Farm condensate by passing through activated carbon prior to passage through clinoptilolite, improve appreciably the ability of the mineral to remove cesium-137. MPP Run 13 was performed to measure more carefully the difference in cesium decontamination factor with and without pretreatment of the feed. While the pretreatment during the run was quite effective in removing organic, the results disagreed with those obtained earlier. The clinoptilolite removed cesium with a decontamination factor of 500 to 800 with feed pretreatment and with a decontamination factor of 1000 to 1400 without feed pretreatment. The manufacturer of the activated carbon indicates that it contains a small amount of water soluble ash, part of which is potassium. Early MPP runs used activated carbon which has been vigorously washed. The activated carbon used in Run 13 received little washing. Since potassium can compete with cesium in the ion exchange reaction with clinoptilolite, there is a possibility that potassium was being leached out of the carbon during the run causing a reduction in the cesium removal efficiency of the clinoptilolite bed.

BIOLOGY AND MEDICINE - 6000 PROGRAM

Geology and Hydrology

The surface of the "blue clays" portion of the lower Ringold formation is an unconformity or erosion surface similar to that on the top of the Ringold formation beneath the Hanford Works area. At least one channel was cut in that lower surface and filled with gravels of the Ringold conglomerate; the channel filling material is more permeable and of lower exchange capacity than the material in which the channel was cut. This is similar to those channels in the Ringold surface, filled with recent fluviatile gravels.

The one channel identified trends southeastward from near 200 East Area toward the 300 Area, hence does not parallel channels on the Ringold surface. Limited evidence suggests its presence beneath 100 B Area. Ground waters in the Ringold conglomerate may move into the channel hence in directions differing considerably from those of shallower ground waters.

The gravel which forms the lowermost bed of the Ringold formation and lies directly upon basalt was shown by recently completed wells to thin to the east and southeast. Correlation of the data to those from other wells and geologic interpretation disclose that the bed evidently is an alluvial fan deposited by an eastward-flowing stream. It thins northward, grades and interfingers into finer material to north, east, and southeast and is overlain by silts and clays. Thus, it more likely is part of the Ellensburg formation, deposited by an ancestral Yakima River, than Ringold, deposited by the early Columbia River.

Development of the refined program for solving the non-linear differential equations for partially saturated flow was completed and preliminary results were obtained. In addition to the fundamental value of the resultant improved understanding of ground water flow, the equation systems are expected to apply to such problems as the evaluation of monitoring facilities for detecting leaks in buried waste tanks.

A mathematical model was developed that permits the determination of stream-lines for a two-source problem. The model was used to study the shape of flow lines beneath a crib as they intersect the capillary fringe above a flowing water table. An example calculation was performed for an eight-foot square crib with the bottom 28 feet above the water table. The crib flow relative to the flow rate of the ground water established the point at which water from the crib enters the water table. The model may be applicable to evaluation of monitoring well locations.

Soil Chemistry and Geochemistry

The incorporation of uranyl ion during the calcite-fluoride replacement reaction was previously found to be directly related to the amount of dissolved oxygen in the fluoride solution. It was postulated that the substitution of $(UO_4)^{-2}$ for $(CaF_4)^{-2}$ might be responsible. The incorporation mechanism was investigated further. To substantiate that an inverse relationship between temperature and uranyl ion removal exists during the calcite-fluoride reaction, a one-half replicate factorial experimental design was utilized. It was found that temperature is highly significant at the 99 percent confidence level. From theoretical considerations it was determined that the addition of sodium sulfite to these systems would remove dissolved oxygen without reducing U(VI) to U(IV). Experiments were therefore

performed both with and without the addition of sodium sulfite and the effect of temperature on the two systems was compared. In the sulfite-containing system, uranyl ion removal increased at higher temperatures in marked contrast to the inverse temperature effect observed in the other system. This tends to confirm the importance of a uranyl ion-oxygen combination in uranyl ion removal from such fluoride solutions. The experiments also indicated the existence of another removal mechanism involving uranyl ion without oxygen.

A laboratory investigation was initiated to study replacement reactions involving sulfide and arsenosulfide minerals. Initial experiments were designed to study the minerals chalcopyrite ($CuFeS_2$), arsenopyrite (FeAsS), and sphalerite (ZnS). A radiocation, Zn-65, and a radioanion, P-32, were selected to begin this investigation. Variables to be studied include solution pH, salt concentration, column flow rate, mineral grain size, temperature and solution oxygen content. Preliminary results indicated effective removal of Zn-65 from solution by chalcopyrite while little or no P-32 removal was obtained with sphalerite. The arsenopyrite bed undergoes severe oxidation under experimental conditions giving a colored effluent with a tendency to produce flocculent, brown precipitates, probably ferric hydroxide.

Field Apparatus Development

The equipment and method for inserting six 1-1/2 inch diameter plastic piezometer pipes simultaneously into an eight-inch well proved successful. The pipe inserted to the greatest depth was over 500 feet long.

Well 299-11-2 was equipped with such piezometer tubes to permit the measurement of head at six depths below the water table. The system will also permit sampling from these depths. Each tube is sealed at the bottom and perforated in the lower 25 feet. The perforated section is contained in a 30-foot bed of sand packed in the original well casing and sealed with a 30-foot plug of pressure grouting. When installation is complete this facility will permit evaluation of vertical differences in piezometric head, which may have significance in ground water sampling performance.

A commercial particulate and gas monitoring system was calibrated and tested. The system, a prototype of an improved model, generally met the vendor claims, although several changes which would further improve the unit were recommended.

A scintillation well probe for gamma logging two-inch diameter wells was assembled and a special detector for the gamma spectrometer was designed.

Protective Agent Studies

Electron spin resonance measurements were made on solid erioglaucine dye, radish seeds, and irradiated radish seeds. The spectrum of the dye showed a broad singlet absorption about 2000 gauss wide with a super-imposed small resonance absorption. The small resonance absorption represented about 10^{16} spins per gram. Radish seeds had a resonance absorption about 10^{15} spins per gram. After Co-60 irradiation to give an absorbed dose of 10^5 rads, the radish seeds had a spin concentration of 10^{17} spins per gram. This latter spin concentration is decreasing with time with a half-life of about six days. These studies show that unpaired electron spins exist in unirradiated materials of interest in radiation protection studies, that more are produced on irradiation, and that these latter spins have relative long lifetimes.

Paper electrophoretic comparison of defibrinated swine blood and the same blood incubated with erioglaucine showed that some component in the blood combines with erioglaucine to form a distinct species. It is interesting to speculate that this combination might represent a means by which erioglaucine effects the observed protective action, namely by shielding a radiation sensitive site from attack by free radicals.

L. P. Bupp
Manager
Chemical Research and Development

LP Bupp:cf

BIOLOGY LABORATORY

A. ORGANIZATION AND PERSONNEL

Dr. H. A. Kornberg is attending the General Electric Company's Advanced Management Course at Crotonville, New York.

B. TECHNICAL ACTIVITIES

FISSIONABLE MATERIALS - 2000 PROGRAM

BIOLOGICAL MONITORING

Radioiodine Contamination

Routine collection of jack rabbit thyroids for purposes of monitoring radioiodine contamination was discontinued.

Columbia River Contamination

Fish

Concentrations of gross beta emitters in all species of fish from the Columbia River continued to decrease during the month, reflecting decreased metabolic activity resulting from lower water temperatures. Average concentrations in whitefish flesh at Ringold were approximately twice those observed last year; the average value in flesh of seven whitefish taken at Priest Rapids was about one-fifth those obtained at Hanford and Richland.

Specific values for fish flesh at all sampling locations follow:

Sample Type	Location	Collection Date	No.	μc/g Wet Weight Average	μc/g Wet Weight Maximum	Trend Factor
Whitefish Muscle	Priest Rapids	Dec. 18-21	7	1×10^{-4}	4×10^{-4}	-3
	Hanford	Jan. 4	11	5×10^{-4}	9×10^{-4}	-2
	Richland	Dec. 14-15	8	6×10^{-4}	2×10^{-3}	--
	McNary	Dec. 27-29	2	8×10^{-5}	9×10^{-5}	-11
Sturgeon Muscle	Priest Rapids	Dec. 19	2	1×10^{-5}	1×10^{-5}	--
	Hanford	Jan. 5	1	3×10^{-5}	3×10^{-5}	
S.M. Bass Muscle	Hanford	Jan. 4	1	1×10^{-4}	1×10^{-4}	
Squawfish Muscle	Hanford	Jan. 4-5	5	2×10^{-4}	8×10^{-4}	
C.S. Sucker Muscle	Hanford	Jan. 4-5	5	5×10^{-4}	8×10^{-4}	
	Richland	Dec. 14-15	2	4×10^{-4}	4×10^{-4}	--
	McNary	Dec. 28	3	1×10^{-4}	2×10^{-4}	
F.S. Sucker Muscle	Richland	Dec. 15	5	3×10^{-3}	4×10^{-3}	--

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(Continued)

Sample Type	Location	Collection Date	No.	µc/g Wet Weight Average	µc/g Wet Weight Maximum	Trer Facto.
Steelhead Trout Muscle	Hanford	Jan. 4	1	3 x 10^{-5}	3 x 10^{-5}	
Chiselmouth Muscle	McNary	Dec. 28	5	3 x 10^{-4}	7 x 10^{-4}	
* Minnows	Hanford	Jan. 3-4	8	4 x 10^{-3}	5 x 10^{-3}	-3
entire	Richland	Dec. 14	5	5 x 10^{-3}	5 x 10^{-3}	-2

* Converted to shiner activity.

Waterfowl

Concentrations of total beta emitters in flesh of game species of waterfowl collected from the Columbia River decreased slightly from last month. Present values are comparable to or slightly greater than those in waterfowl obtained in late January last year. Average concentrations in flesh of various species follow:

Sample Type	Collection Date	No.	µc/g Wet Weight Average	µc/g Wet Weight Maximum	Trend Factor
Diving Ducks	Jan. 6	6	2 x 10^{-3}	6 x 10^{-3}	--
River Ducks	Jan. 5-6	9	4 x 10^{-4}	2 x 10^{-3}	-2
Merganser	Jan. 6	4	1 x 10^{-3}	2 x 10^{-3}	+4
Coot	Jan. 5	1	4 x 10^{-5}	4 x 10^{-5}	--
Goose	Dec. 15	1	1 x 10^{-5}	1 x 10^{-5}	--

Heads of 78 waterfowl were obtained from local sportsmen and scanned for gamma emitters. Fifty per cent were above the established background of 25 total gamma counts per minute. Further analysis identified P^{32} as the contributor of 90 per cent of the total beta radioactivity.

Swamp Contamination

Average concentrations of fission products measured as total beta emitters in flesh of game species of waterfowl collected at the 200 West swamps in mid-December were twice those obtained during October and approximately one-fifth those of one year ago. Cs^{137} has previously been identified as the major contributor of radioactivity in waterfowl at this location. Average concentrations in flesh of various species follow:

Sample Type	Collection Date	No.	µc/g Wet Material Average	µc/g Wet Material Maximum
River Ducks	Dec. 12-15	4	2 x 10^{-4}	3 x 10^{-4}
Diving Ducks	Dec. 15	3	4 x 10^{-5}	6 x 10^{-5}

Waterfowl Populations

Aerial census along the Columbia River from the mouth of the Yakima River to Priest Rapids Dam revealed a total of 147,000 ducks and 14,000 geese utilizing that area. This is about the same number of ducks and ten times as many geese as observed last year. Eighty per cent of the geese were migrating lesser Canada geese.

Effect of Reactor Effluent on Aquatic Organisms

Effluent monitoring was continued at the 1706-KE laboratory with the exposure of young salmon to dilute untreated effluent and to like concentrations of effluent passed through a bed of aluminum turnings. Mortality substantially above that of the control lots has occurred, as anticipated, in the highest (8 per cent strength) effluent concentrations, but there is no indication that the aluminum turnings have affected the toxicity.

C. cclumnaris

Studies with columnaris organisms isolated during the past summer showed virulence differences. A strain isolated when river temperature was 68 F was most virulent, a strain isolated from 61 F water was next, and a strain isolated from 66 F water was least virulent. While these data are preliminary, at this time, there does not appear to be a direct relationship between water temperature and virulence. None of these cultures were as virulent as the strain originally obtained from Dr. Ordal.

BIOLOGY AND MEDICINE - 6000 PROGRAM

METABOLISM, TOXICITY, AND TRANSFER OF RADIOACTIVE MATERIALS

Strontium and Calcium

Whole-body monitoring continued on representative swine fed 1 and 25 μc/day of Sr^{90} for prolonged periods of time. On the basis of counts made on standard carcasses bearing known amounts of Sr^{90}, the animals fed 1 μc/day for 9 to 23 months from the age of 9 months had body burdens estimated to be 10 to 15 μc. A Sr^{90} body burden of 300 μc was detected in a few animals 15 months old that were farrowed and suckled by sows fed 25 μc/day and then placed on the 25 μc/day feeding level. Verification of these counts will be obtained when representative animals are sacrificed and analyzed.

It was observed that reasonable counting values are obtained in the whole-body monitor from the K^{40} in the control swine. This finding may prove valuable for future metabolic studies as a reference value for effective cell or muscle mass.

It was observed that additions of calcium gluconate up to 220 grams twice daily (6-9 x normal calcium) in the diets of ewes had no appreciable effect on the relative binding of Sr^{90} and Ca^{45} added in vitro to serum from the ewes. However, (contrary to previous expectations) a difference was observed between the binding of serum calcium and the Ca^{45} that was added in vitro. Between 30

and 50 per cent of the serum calcium did not appear to be traced by the Ca^{45} added in vitro and therefore probably irreversibly bound to serum proteins or molecules greater than 20 angstroms in diameter. Further studies are planned to determine the source of the bound calcium.

The excretion of Sr^{90} and Ca^{45} intravenously injected into the intestine of rats has been studied using the technique of in situ perfusion of the intestine. Data thus far obtained indicate quite clearly that there is no discrimination between strontium and calcium in this process. Whether the rate of excretion is influenced by the calcium concentration of the perfusing solution has not yet been clearly demonstrated. The effect, if any, is small.

Leukopenia has developed in at least some rainbow trout five months after the termination of feeding of Sr^{90}-Y^{90} at a rate of 0.05 μc/g of body weight per day. The white blood cell count in the affected fish is about 4000/mm^3 compared with about 40,000/mm^3 in control fish. No leukopenia was evident last July at the end of 21 weeks of isotope administration. A few of the surviving fish in this test have spawned and it is hoped that egg survival can be used as an additional parameter of damage.

Tests with Evans Blue dye in gelatin capsules (like those used in force feeding of Sr^{90}) showed that a food bolus passes through the g.i. tract of trout in about 24 hours.

Results from three tests with Ca^{45} in the trout gill perfusion technique indicate that calcium moves from the environmental water across the gill membrane about four times faster than strontium.

The effect of 2,4 dinitrophenol (DNP) on water and calcium uptake by barley is pH dependent. At pH 6.0, a concentration of 2×10^{-4} M was required to cause the same effect as caused by 7.5×10^{-6} M at pH 4.0. These data indicate that DNP is not as readily taken up by plants at higher pH. This, in part, reconciles our results with those obtained by other workers.

Cesium and Potassium

In the sheep gonad dose study employing Cs^{137}, it was noted that the soft tissues of the rams had radiocesium concentrations 10 to 30 times the plasma concentrations. Voluntary muscle concentration was 25 to 30 times the plasma level. Turnover rates for voluntary muscle and blood cells were about 10 per cent per day, whereas heart muscle and the majority of other soft tissues had turnover rates exceeding 200 per cent per day.

On the basis of radiation dose measurements, gonads and whole body were equally important as the "critical organ" in sheep receiving Cs^{137} daily. Approximately 20 to 25 per cent of the gonad dose originated in contiguous structures. The highest dose rate was obtained in kidneys and was approximately twice the total body or gonad dose rate.

Further studies on the effect of moisture stress on Cs^{137} and potassium uptake in bean plants showed that increasing soil moisture tension increased Cs^{137} uptake

b- plants growing in soil fertilized with carrier cesium to the s:me extent as in plants grown in soil without these treatments. Potassium uptake was not affected by soil moisture when carrier cesium and fertilizer were added.

Plutonium

In the study involving plutonium injected intradermally into swine, it was found that scabs which formed at the higher- level sites contained over 80 per cent of the retained dose two to three months post injection. In one miniature swine seven months after injection, the 1 and 5-μc sites from which scabs were removed contained less than 5 per cent of the injected dose. In another animal five months after injection, 1 and 5-μc sites from which the scabs were not removed (and appear to be still intact) contain 30 to 50 per cent of the injected dose and the 0.2 and 0.4 sites (scabs intact) contain only slightly less than the higher level sites. This suggests either that the scabs may have been partially lost due to flaking, or that translocation has taken place.

The injection of plutonium citrate (approximately 30 μc/kg) either 30 minutes prior to or 30 minutes following 500 r whole-body X-irradiation resulted in the death within 30 days of 23 out of 24 rats. A similar experiment in which the plutonium was injected as the DTPA chelate resulted in no deaths. The situation is not quite so clear cut when the plutonium is administered as the citrate followed after various intervals by the administration of DTPA. Early treatment with DTPA appeared to decrease mortality but the data are as yet too limited for statistical significance.

Radioactive Particles

In rats exposed to $Ce^{144}O_2$ aerosols with a mean particle diameter of about 0.2 micron, lung clearance was very rapid. Other experiments are in progress with larger $Ce^{144}O_2$ particles to determine the relationship between particle size and lung clearance. In studies with $Pu^{239}O_2$ particles an effect of particle size on lung retention and urinary excretion was indicated. Since these findings are considered important to inhalation hazard evaluation and to bioassay interpretations, they are being examined further.

Ninety rats were exposed to Paducah dust for determination of the acute toxic dose. Only three rats are dead three weeks post-exposure.

Of 28 dogs exposed to plutonium dioxide aerosols one year ago to determine the relationship between dose and early toxicity only two survive. This experiment is providing a good basis for planning exposure levels for long-term, multiple-exposure experiments and has given much information on the toxic syndrome of inhaled plutonium.

Evidence has been obtained for the entry of insoluble cerium oxide particles (0.1 to 0.2 μ diameter) into bean leaves. A small fraction of the deposited material was subsequently translocated to young growing tissues over a 48-hour period. The degree of insolubility of cerium oxide particles is currently being studied.

Effects of Irradiation

No delay in the onset of growth was observed in continuously irradiated (1250 rad/hour) haploid and diploid yeast cultures. However, growth rates of irradiated cultures were less than controls. Growth rates of haploid cultures were more depressed than diploid cultures. Comparisons of total number of cells to viable cells at intervals during the experiment indicate that depressed growth rates in the irradiated cultures were primarily due to radiation inactivation of cells rather than delayed division.

Soil algae (Microcoleus vaginatus) were exposed to different dosages of X-radiation. Dosages to 100,000 r did not decrease chlorophyll production.

Studies were initiated to determine the distribution of sodium and potassium in sub-cellular fractions of the regenerating liver. Limited data thus far available indicate that the "supernatant fraction" contains the highest concentration of sodium and potassium; that the regenerating liver contains higher sodium and potassium levels than the normal liver and that the results obtained are quite sensitive to the procedures employed for freeing the tissues of blood.

R. F. Foster

Acting Manager
BIOLOGY LABORATORY

RF Foster:es

C. Lectures

a. Papers Presented at Meetings

* None

b. Off-Site Seminars

L. K. Bustad, January 13, 1961, Graduate lecture to staff and student body, Texas A & M College, College Station, Texas.

R. T. O'Brien, January 19, 1961, "Cytologic Effects of Radiation," Radiation Biology Seminar, University of Washington School of Medicine, Seattle, Wash.

J. J. Davis, January 20, 1961, "Project Chariot Environmental Studies," Yakima Junior College, Yakima, Wash.

* W. C. Hanson, January 24, 1961, "Project Chariot Environmental Studies," American Society of Professional Engineers, Walla Walla, Washington.

R. F. Palmer, January 19, 1961, "Radiation Biology at Hanford," Rotary Club, Prosser, Washington.

M. F. Sullivan, January 25, 1961, "Effects of Radiation on the Gastrointestinal Tract," Exchange Seminar Program, Washington State University, Pullman, Wash.

S. Marks, January 26, 1961, "Histopathology of Radiation Damage," Radiation Biology Seminar, University of Washington School of Medicine, Seattle, Wash.

L. K. Bustad, January 31, 1961, "Influence of Atomic Energy on Agriculture," Annual Farmers' Day luncheon of Moses Lake Chamber of Commerce, Wash.

c. Seminars (Biology)

D. A. Barber, "The movement of oxygen through plants," January 25, 1961.

J. D. Stewart, "The influence of soil moisture stress on the uptake and translocation of cesium-137 and potassium in plants," January 25, 1961

D. Publications

a. HW Publications

None

b. Open Literature

Thompson, R. C., "Vertebrate Radiobiology: Metabolism of Internal Emitters," Annual Review of Nuclear Science 10, 531-560 (1960).

OPERATIONS RESEARCH AND SYNTHESIS OPERATION
MONTHLY REPORT - JANUARY, 1961

ORGANIZATION AND PERSONNEL

There was no change in organization or personnel during the month of February.

OPERATIONS RESEARCH PROGRAMS

Inventory of Models

An inventory of different business models at HAPO has been started in an effort to better understand the data available. Models concerning unit cost, profitability, and productivity originating in the Financial components at HAPO and the net return model originating in Irradiation Processing Department have been studied and the differences from other models noted.

OPERATIONS ANALYSIS STUDIES

Fuel Element Performance

The two programs previously referred to as the "Quality Certification Program" and the "Fuel Element Failure Program" have been combined, together with production test and fuel element corrosion analyses previously reported under services to IPD. The activities being carried on in these areas are all closely related. The combined program will be called the "Fuel Element Performance" program.

A thorough analysis was made of post irradiation data from production test IP-262 A, relating to an evaluation of the bumper fuel element. It was found that the fuel element distortion that occurred was the same for the bumpers and control nonbumpers; that the amount of warp observed was about as expected based on the mathematical model previously developed from Quality Certification data; and that the frequency of hot spots observed on the nonbumpers agreed very well with that predicted. The bumpers appeared to be effective in drastically reducing hot spot formation in some tubes, but almost totally ineffective in others. Assistance was given personnel from IPD in making a presentation of these results to management and technical personnel from FPD, IPD, and HLO, and specific recommendations were made for further action. A document will be issued summarizing results from this test.

Data from this test were also used to gain more information on the uniform corrosion mechanism. Since long residence times were involved, the weight losses were substantial. Strong evidence was found of preferential corrosion attack on part of the fuel element, which indicates that corrosion is not truly uniform and, consequently, that the corrosion limit may be considerably closer than formerly expected.

Additional work is being done to develop models relating fuel element distortion to reactor variables. In particular, diameter growth at the ends of the fuel elements has been investigated. However, core temperature was used as opposed to surface temperature, and it is felt that improved results can

be found using surface temperature. This may be due to the effect of corrosion, which is strongly temperature dependent, on the measured fuel element. The improved fit using surface temperature rather than core temperature was found for the other measures of fuel element distortion. Revised models, based on the complete file of Quality Certification data, will be developed within the next few weeks.

Revised graphs were prepared exhibiting dimensional distortion, with the effects of reactor variables removed, as a function of canning date. About 135 lots are now included, extending over a period of about 14 months. Rather drastic cycles in metal quality, as measured by distortion, continues to exist.

Process Tube Leak Detection and Replacement

A rough draft report was issued presenting the results of the study concerned with predicting internal corrosion of process tubes. The model used was developed some months ago, and was recently tested on complete tube corrosion data from B reactor. Promising results were achieved on these B reactor data. Similar work will now be done on data from other reactors with the possibility of replacing current methods of estimating internal tube corrosion by methods based on this model.

Z-Plant Information Study

Coding for the computer is 99% complete. Desk debugging is 85% complete. Some delay in machine debugging is expected because the compiler routine submitted de-optimized the coding, making the program overflow the memory available and requiring 1500 out of 6000 instructions to be changed to a new format. In addition, the simulator program provided did not function properly. The installation and maintenance engineers for the computer arrived late in January and have been escorted into the plant area to investigate installation problems.

Analytical investigation related to defining the last sections of the program indicated two difficulties in the RMC production line design and operating limits: (1) The omission of a breakout facility to serve the recycle furnaces, and (2) the fact that the critical mass limits pertaining to the various new facilities may affect the increased production efficiencies designed into them. These have been brought to the attention of the CPD personnel responsible for review and correction.

Radiation Protection Studies

Standard curves for interpretation of dose from different personnel badge readings have been submitted to Radiation Protection. It has been determined that a curve represented by the equation

$$\text{Log}\left(1 - \frac{\text{density}}{K}\right) = a + bD$$

and

$$D = a' + b' \log\left(1 - \frac{\text{density}}{K}\right)$$

[redacted]

1234137

represents the data as well as the cubic polynomial now in use and, through some simplification of the three parameters, is more easily calculated.

Reliability Studies

A specific problem involving the trip logic of a safety circuit and the resultant reactor operating continuity was solved.

STATISTICAL AND MATHEMATICAL ACTIVITIES FOR OTHER HAPO COMPONENTS

Fuels Preparation Department

Assistance was given in the design of a test involving the irradiation of co-extruded fuel elements in the K reactors to obtain a preliminary evaluation of the capabilities of the co-extrusion process.

Data from component wettability tests were analyzed to test for differences between evaluators and between lots, and also to obtain a better estimate of the residual variability. These results will be used in establishing acceptance tests for aluminum components based on wettability properties.

A binomial sequential sampling plan with two-sided alternative was developed for use in controlling tester error associated with operation of the total bond count tester. Formulas for average sample numbers were also found.

Irradiation Processing Department

A study is being made of safety factor requirements for front header pressure to prevent cavitation in the orifices. Submitted data indicated that true differences between orifices were quite large, necessitating fairly substantial safety factors. However, it was pointed out that since measurement error was evaluated by successively measuring the same orifice, there is a definite possibility that the measurement error was underestimated, and the variation between orifices was consequently overestimated. An experiment was subsequently designed to obtain valid estimates of the various error components.

Chemical Processing Department

The last of the formal presentations on experimental design was given to members of the 234-5 Development Operation. It is tentatively planned to continue meeting periodically with the group in discussing specific problems encountered in their experimental work.

An analysis was made of spectrographic data from buttons produced during December. As a result of this analysis, serious problems concerned with correctly assessing the impurity content of a given button have arisen. Further work will be done in this area in connection with the broader program of evaluating the effects of process variables on button purity.

[redacted] Dean represented HAPO at the biannual meeting of the Numerical Control Subcommittee of the Committee on Super Accuracy held at Oak Ridge on January 19 and 20.

Technical consultation continued on mathematical solutions to a variety of neutron diffusion problems arising in the shielding and design studies for a proposed shipping container.

STATISTICAL AND MATHEMATICAL ACTIVITIES WITHIN HLO

2000 Program

Reactor Studies

A theoretical equation used to calculate buckling values is being reviewed for effectiveness by examining the residuals consisting of calculated minus experimental values under a variety of enrichment and rod diameter conditions.

Chemical Development

Closed form solutions to a simultaneous set of 3 nonlinear partial differential equations were obtained. The equations represented a model for the heat transfer in a long gas-catalytic reactor.

Materials Development

Surface oxide buildup data were fitted to a theoretical curve in a static CO_2 graphite experiment.

Fuels Development

Assistance is being given in the development of a mathematical model to express AlSi grain structure as a function of temperature and exposure. Use is being made of a visual index to characterize this grain structure.

4000 Program

Plutonium Recycle Program

A report was issued concerning economical groupings in 100% inspection schemes. This was motivated by leak testing of PRTR fuel elements.

Nondestructive Testing

Mathematical aid continued to Physical Measurements in support of their program of analyzing and interpreting the significance of signals received from various nondestructive fuel element testing devices.

Chemical Effluent Technology

Mathematical analyses continued for Geophysical and Geochemical Research in support of their program for determining the diffusional and transport characteristics of radioactive materials in soil and ground water.

6000 Program

Biology

Initial work was completed on the provision of error estimates of some random variables occurring in a multichannel analyzer problem, and the results were reported orally to interested personnel of the Biology Operation.

General

Instrumentation

The statistical analysis of RST #4 potentiometer calibration data was completed for the Instrument Research and Development Operation. Calibration curves and their appropriate confidence statements were determined for different operating conditions of the potentiometer at room temperature. Also, the analysis investigated the precision of the instrument at higher temperatures.

Work Sampling Study

The final observations were made on January 23 for the work sampling study being conducted by Analytical Laboratories Operation. The data are being compiled for a complete statistical analysis.

Division of Research Programs

Work was begun on the application to this program of techniques developed in connection with reliability studies. In particular, the systems reliability approach is being exploited and several new techniques have been developed.

Work on both the time and exposure dependence of plutonium isotopic compositions is being done using both an analytical and an empirical approach.

Other

At the request of a member of HLO, Chemical Research and Development, a mathematical problem associated with ion exchange phenomena was solved. Current efforts are directed toward a two-dimensional generalization of the problem.

Carl A. Bennett, Manager
Operations Research & Synthesis

CAB:kss

PROGRAMMING OPERATION
JANUARY 1961

A. REACTOR DEVELOPMENT - 4000 PROGRAM

1. PLUTONIUM RECYCLE PROGRAM

Computer Code Development. The efforts to adopt the same reactor physics logic used in the Specific Fuel Cycle calculations also in the generalized plutonium recycle studies (PUCK Code) are nearing completion. Several of the defined physics parameters must be slightly varied in their definition to account for the differences introduced by the updating. It is believed that these corrections have been made and a remaining small difference in results appears to be due to differences in the methods of converging in that portion of the program that examines uranium enrichment. A uniform definition of convergence has been formulated and appears to resolve the differences. The resulting PUCK Code employing the updated physics methods is defined as PUCK II and the former deck is known as PUCK I. There are slight differences in the economic formats of these decks which are being reconciled. The PUCK II deck is further being adjusted so that it can be reconciled with the economic codes of the specific fuel cycles program known as QUICK. The final rough draft of a report describing the PUCK I program as it has been used to date is nearing completion. This code yields essentially the same results with uranium enrichment as PUCK II or the QUICK Code. It yields pessimistic results with plutonium enrichment, as was recognized when the code was formulated three years ago. Considerable data have been developed with this deck for uranium enriched reactors. These data have been used for the stainless steel cladding analyses and for development of general trends with regard to reactor specific power and uranium price schedules.

Work, temporarily interrupted because of APWR studies, was restarted on a broad program concerned with evaluating the reactivity worth of various mixtures of plutonium and uranium isotopes as fuels in several different types of reactors. Approximately 500 separate cases have previously been calculated under assumed batch exposure conditions and require tabulation and evaluation. Outline methods of securing and editing the required data with the aid of the IBM-7090 were made and discussed with Data Processing personnel.

Specific Fuel Cycle Analysis. January saw the completion of fuel cycle computations for the Beloyarsk Russian Superheat reactor, which provided a convenient check of the codes and results of specific fuel cycle work to date. Plutonium fueling with batch irradiation in eight recycle series was studied. Five different k_{∞} values were used and, in addition, extra cases were rerun to evaluate the possible effect of allowances for different moderator temperature coefficients. Batch irradiation was used to conform with intent of the Designers. Checks are being made with graded discharge

as plutonium values and fuel costs are usually lower when evaluated in graded rather than batch modes, and the probability of operators converting to graded cycles is great. Generally speaking, the higher the initial enrichment value of the fuel in a batch cycle, the larger the fuel exposure and the lower the fuel costs. However, variations in reactivity during a batch irradiation must be handled by control rods and/or burnable poisons, the cost of which is difficult to determine. Rigorously, these costs should be included as part of the fuel cost for each value of initial enrichment. To avoid this, fuel cost and plutonium value analyses were performed over a range of initial enrichment values and it was possible to select one which appeared plausible all things considered.

It was found by plotting the fuel costs for the uranium base cases that a plutonium minimum cost was determined at initial k_{∞} of 1.25. Therefore, this recycle series should probably be used as a standard for the batch cycles when examining the effect of the economic parameters on plutonium values in this reactor.

Coincidently, the calculated plutonium values in this series are of the order of \$14/gram, which has been found to be the mean value in a similar analysis in a water moderated reactor (APWR).

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

While lower initial k_{∞} gave higher costs, detailed examination was also made for an initial k_{∞} of 1.065, which is representative of the actual Russian design. Under these conditions plutonium can have a higher value if one allocates to the productiveness of plutonium the smaller change in reactivity from cold to hot moderator associated with plutonium as compared to uranium-235 enrichment. If one does this, plutonium values of \$30 to \$40 per gram are calculated. It appears precarious, however, to allocate to plutonium this value, in view of the fact that the use of burnable poisons permits such an effective increase in initial k_{∞} that, in effect the change due to different temperature coefficients is negligible. If burnable poisons are not permissible, and the control system limits the initial k_{∞} to 1.065, then the validity of the temperature coefficient argument to the value of plutonium is extremely important.

Without a temperature coefficient bonus at low values of initial k_{∞}, plutonium values are negative by as much as $150/gram. The reason for this is that the fuel exposures are limited to about 2000 MWD/T which produces plutonium very high in plutonium-239. This plutonium, in turn, when inserted into the reactor brings the reactivity to the control rod limit at very low fissile densities. These densities of plutonium, in turn, are not sufficient to support an economic fuel exposure.

The computer programs used for this computation have been arranged to print out a complete report which is reproduced directly from the computing machine. The report relates the plutonium value as a function of the many parameterized variables in a manner such that they can be examined by scanning the summary sheets. In this form, the data can be used to facilitate the optimization of the over-all design with regard to total power costs and fuel cycles. Preliminary examination of graded, rather than batch, irradiation of fuels in this Russian machine appears to reduce fuel costs by roughly a factor of two.

Stainless Steel Fuel Cladding. The final draft of the study of the exchange of cladding materials such as zirconium and stainless steel in various reactor and economic climates is nearing completion. A brief resume of this study was given in a one-hour talk to Hanford people. Fuel development personnel expressed the opinion that they could use these results to aid in answering a large number of questions about the desirability of various approaches toward an economic fuel element. A slight expansion of the data presentation will facilitate using the material for other purposes.

The fuel costs generated during the study of alternate cladding materials are proving of value in assisting the Reactor Engineering Development Operation with the preliminary portion of a supercritical reactor study. Specifically, the data allows one to estimate the consequences on total fuel costs of choosing various fuel element geometries and coolants.

PRTR Fuel Procurement and Scheduling. Satisfactory resolution of the problems relating to the timely procurement of about 40 Kg of high-exposure plutonium for the recycle program continues. In this period decisions were completed for the receipt at HLO and processing to metal by May of this year the one kilogram of 17% Pu-240 material in an accumulation of plant flushes at ORNL. Additional lots of high-exposure plutonium from several sources are now scheduled for recovery either at ORNL or SRP during CY-1961. These sources include plutonium being irradiated at SRP, MTR Pu fuel assemblies further irradiated in the ETR, and one lot of material from AECL. By mid-calendar 1961 Hanford should receive approximately 20 Kg of 20 per cent Pu-240 material plus 0.9 Kg of 40 per cent material, and by the end of the calendar year an additional 17 Kg of 20 per cent material plus 1 Kg of 40 per cent material.

Planning was accelerated during the month to develop streamlined administrative procedures for the conduct of special irradiation experiments in the PRTR. A proposed format for obtaining approval to conduct experiments in the PRTR was prepared by PRTR operating personnel, and discussed with Programming and the primary R&D customers. Special emphasis was placed on facilitating joint sponsorship of experiments by more than one group to maximize the amount of useful new information obtained from each test, and on minimizing adverse interactions of separate experiments in the reactor. A nominal two-week (12-13 day) operating schedule appears preferable to a one-week cycle, because the resulting longer shutdown period between cycles permits more effective scheduling for maintenance and experimental changes.

B. OTHER ACTIVITIES

The Hanford Laboratories Plant Improvement Report was completed and issued during January, covering the five-year period FY-1962 through FY-1966. Although contingent on AEC approval and funding of the individual projects and facilities additions, the report covers present planning for major construction projects, equipment, and equipment projects during the five-year period.

In response to a request from the AEC, a secret document was prepared answering specific questions relating to temperature and radionuclides in the Columbia River. The AEC has also requested preparation of an unclassified version of this report. The Columbia River situation was also reviewed with personnel from the Portland Office of the Corps of Engineers.

The radiation protection problems associated with the use of radioactive heat sources were reviewed with Mr. G. A. Riedesel, Division of Industrial Research, Washington State University.

A list of 74 names of Hanford Laboratories technical specialists was compiled and submitted to the General Electric Materials Specialists Council for inclusion in the GEMS Directory.

The Hanford Laboratories inventory of standard visual aid charts was reviewed and updated, and obsolete charts were destroyed.

Assistance was provided in arranging for visits and tours by 65 individuals for 28 visits. This included a DRD Mid-Year Budget Review with five Washington-DRD personnel, and a two-day technical information exchange with Dr. C. G. Suits of GERL, and five of his Department Managers.

F. W. Woodfield

Acting Manager,
Programming

FW Woodfield:rd

RADIATION PROTECTION OPERATION REPORT FOR THE MONTH OF JANUARY, 1961

A. ORGANIZATION AND PERSONNEL

Effective January 1, 1961, L. A. Carter was transferred from IPD to the Radiological Evaluation Working Group. The force of the Radiation Protection Operation totals 137.

B. ACTIVITIES

A review of the internal deposition of radionuclides in Hanford employees for the year 1960 indicated there were 28 employees who incurred measurable internal deposition. Eighteen employees received plutonium deposition, nine employees received mixed fission product deposition, and one received a deposition of uranium. The body burden in all cases was equal to or less than 10% of the maximum permissible body burden. Additionally, 23 employees received low level and transient deposition of uranium in the course of their work. Inhalation and the contaminated minor injury remained as the principal modes of exposure for internal deposition of radionuclides in HAPO employees. Eighteen skin injuries involving surface contamination required checking in the Whole Body Counter during the year. Three of these eighteen injuries had imbedded contaminants to a level that required excision of tissue. As of the end of 1960 there were six employees and one subcontractor employee who had some form of radiation work restriction as a result of internal deposition of radioactive materials.

One minor case of plutonium deposition was confirmed during the month. The total number of plutonium deposition cases that have occurred at HAPO is 264, of which 193 are currently employed.

Four cases of plutonium contaminated minor injuries occurred during January. In two cases, it was necessary to excise small skin sections to remove plutonium. The other two cases involved a minor amount of plutonium which did not warrant medical action. The maximum amount of material involved before excision was 3.5 μc of plutonium; associated with a small metal sliver. After excisions, the maximum amount of plutonium remaining at the wound site as measured by the Whole Body Counter was 5.4×10^{-4} μc Pu.

Two employees received localized skin dose in excess of that planned as a result of protective clothing contamination. The maximum dose involved to a small area of the skin was about 6.4 rads including .035 r.

Exposures to IPD personnel were well controlled during operational work involved in removing enriched metal which had been inadvertently discharged from the reactor on top of the rear face elevator. Measured dose rates were as high as 250 r/hour at 60 feet.

Monitoring services were established on a three-shift basis coincident with the startup of the strontium recovery program at 325-A High Level Facility. In-cell radiations up to 15,000 r/hour were measured. Approximately 60 samples with dose rates up to 25 rads/hour were removed from the cell and processed in the analytical laboratories. Dose rates up to 50 r/hour were measured on the front face of the High Level Radiochemistry Facility, after a strontium feed solution was inadvertently drawn into a reagent fuel line. Alarming devices and subsequent application of remote valving techniques minimized personnel exposure to eight employees in the work area. Whole body dose rates were limited to 50 mr/hour. Dose rates as high as 20 r/hour and 8 r/hour were observed during operations at the loadout hood and waste transfer ports, respectively.

Constant radiation monitoring was required for most construction work at the 340 Building Waste Storage Facility as the result of overflow of tanks causing general contamination up to 200 mr/hour, and dose rates of 1.5 r/hour from waste trailers parked near this facility.

Radiation dose rate measurements obtained during the second group of critical tests at the PRTR included: 3 mrems/hour of fast neutrons in the lower access space at 400 watts power level; 6 mrems/hour of fast neutrons in the upper access space at 1000 watts power level with all water systems filled. With the reflector system dry a dose rate of 33 mrems/hour was measured under the reactor core. General dose rate levels throughout the containment vessel were less than 2 mr/hour. No significant increase in dose rates, external to the reactor, were detected during circulation of moderator poison. Increases in neutron dose rates observe during operation without the reflector indicated that high power operation may may cause excessive piping activation. The need for additional shielding is under study.

A review of the employees assigned to the Plutonium Metallurgy Operation showed an increase in radiation dose in 1960 as compared to 1959. The number of employees with a whole body dose of 1 r or greater increased from ten in 1959 to twenty-eight employees in 1960. The number of employees showing a hand dose in excess of 10 r increased from six in 1959 to thirty in 1960.

Two private residences were surveyed at the request of Chemical Processing Department. Low level contamination of 3,000 d/m Pu and 1,000 d/m Pu on two personal items was discovered. The items were sent to the area for disposition.

Four exempt employees, as members of the Radiological Assistance Team, responded to a request from the Idaho Operations Office for assistance at the SL-1 Reactor Accident site.

The plutonium wound monitor in the 200-W First Aid Station was tested and appeared to provide the desired sensitivity. Two cases with known low level plutonium deposition in their hands were checked and the results were comparable to those obtained using the crystal counter at the Whole Body Counter facility.

The 83 threshold dosimeters distributed throughout HAPO processing and laboratory areas and used to determine dose and energy distribution in the event of a criticality accident were modified in January. Modification involved the sealing of the plutonium, neptunium, and uranium foils and the boron ball portion of the dosimeter in a 1/4 inch stainless steel jacket for contamination control in the event of a fire. The modification was completed in one week and no individual dosimeter was out of service more than 48 hours. The annual exchange of the chemical and glass dosimeters in this criticality dosimeter unit was completed.

The bi-weekly film dosimeter exchange frequency which has been employed in the plutonium processing areas was discontinued after a thorough review. Finger dosimeter exchange frequencies have also been on a bi-weekly basis. Both of these types of dosimeter coverage are now placed on the standard four-week cycle in use throughout the balance of the plant.

The 1958 and 1959 bioassay analytical results for plutonium were microfilmed and the cards were stored in the 3705 retention vaults. Ten exposure summaries were prepared for previous HAPO employees as a result of requests from current employers.

Analysis of the data on the aerial survey measurements which were obtained at the Nevada Test Site in November were completed. A report of the findings was prepared for submission to the Director of this project (60.3) at the Oak Ridge National Laboratory. The principal benefit from the project was the knowledge of where aerial survey systems needed improvement. Modifications to HAPO equipment have been started and design criteria for a new aerial survey system was established.

The automatic Columbia River monitoring station was inoperable for the majority of the month due to instability of the amplifiers and failure of the water pump. Modifications of the hydraulic part of the system were made to permit complete backflushing of the intake lines periodically to minimize sand buildup. Special Columbia River water samples taken following a purge at the 105-B Reactor indicated no significant increase in the concentrations of radionuclides in the river.

The evaluation of the radiological consequences in the environs from a maximum credible accident at the PRP critical facility was completed. As a result of this analysis, it was recommended high efficiency iodine removal equipment be installed in the cell vent system. In the event of an accident, process cell air would be vented to the stack through particulate filters and iodine removal equipment.

A review of all the control limits in use at the PRTR for both gaseous and aqueous radioeffluents was completed. The previously established control limits were revised slightly to promote consistency. A more important change in the containment limits was made to provide more realistic levels at which the drastic action of full containment would be executed automatically.

Work continued on the preparation of a complete set of uniform size drawings showing the location of criticality threshold dosimeters, criticality film kits, criticality alarms, air sampling locations, and remote radiation detection instrument recorders for the entire plant.

Expected doses from prompt gamma and neutrons from a criticality burst were calculated and plotted for various thicknesses of cell walls and distances from the cell wall. Approximations were based on the best available data and the answers should be correct within a factor of four. These calculations were then repeated to determine the dose rate from the delayed gamma for a time period from 10 seconds to seven days after the excursion.

Five prototype personnel dosimeters were fabricated by Technical Shops. This group of prototypes was designed to accommodate metal foils and sulphur for criticality dosimetry; fluorods for high gamma doses; personnel dosimetry film for chronic dose interpretations; and accommodations for a security photo. The design incorporates fully automating the unloading and loading of the dosimeter film. Evaluation of the filter system using open window, iron, plastic, and tantalum filters indicated that an evaluation of uranium beta dose of 100 - 400 mrads could be estimated within 10 percent in the presence of low energy X-rays and more penetrating gamma radiations.

A vibrating reed electrometer in a 40-liter ion chamber was used to measure the dose rates in the 3746 Building from extended Calibrations Operation procedures. Dose rates of 2 mr/hour were measured during full power operation of the Van de Graaf accelerator in the 3745-A Building. These tests were made in anticipation of long-term exposures for studying graphite damage effects currently planned for the Van de Graaf accelerator program.

C. EMPLOYEE RELATIONS

Four suggestions were submitted by personnel of the Radiation Protection Operation. There was one suggestion evaluated and rejected. Three suggestions submitted by Radiation Protection Operation personnel are pending evaluation.

There were four medical treatment injuries during the month for a frequency of 1.73. No security violations occurred during January.

Radiation Protection training included: Two orientation talks to new employees and Minor Construction personnel; a refresher meeting with 300 Area Fire Department personnel covering emergency procedures and instrument training; the Monitoring staff was instructed in the operation of pulse readers and on tritium bioassay dose calculation; a series of radiation orientation and training sessions with the Critical Mass Facility personnnel; and three two-hour orientation talks presented to Biology Research & Nuclear Physics Research personnel.

D. SIGNIFICANT REPORTS

HW-68127 "Analysis of Radiological Data for the Month of December, 1960" by E. C. Watson.

HW-68352 "Monthly Report - January, 1961, Radiation Monitoring Operation" by A. J. Stevens.

HW-67787 "A Portable Dose Rate Instrument for Measurement of Natural Background Levels" by F. L. Rising.

ENVIRONMENTAL MONITORING - RESULTS - (Mid-December 1960 - Mid-January 1961)

Sample Type and Location	Activity Type	Monthly Average	Units
Drinking Water			
100-F Area	Isotopic	1.2	% MPC_w-GI*
Separations Areas	Gross Beta	1.6×10^{-7}	µc/cc
Pasco	Isotopic	< 7.9	% MPC_w-GI**
Kennewick	Isotopic	< 1.2	% MPC_w-GI**
Richland	Gross Beta	$< 3.0 \times 10^{-8}$	µc/cc
Columbia River Water			
Above 100-B Area	Gross Beta	3.0×10^{-9}***	µc/cc
100-F Area	Isotopic	4.6	% MPC_w-GI*
Hanford	Isotopic	3.0	% MPC_w-GI*
Pasco	Isotopic	36	% MPC_w-GI**
McNary Dam	Gross Beta	1.8×10^{-6}	µc/cc
Vancouver, Washington	Isotopic	0.4	% MPC_w-GI**
Atmosphere			
I^{131} Separations Areas	I^{131}	2.0×10^{-13}	µc/cc
I^{131} Separations Stacks	I^{131}	0.8	Combined curie/day
Active Particles - Project	--	2.5	ptle/100 m^3
Active Particles - Environs	--	0.2	ptle/100 m^3
Vegetation (Control limit for vegetation is 10^{-5} µc I^{131}/g)			
Separations Areas	I^{131}	4.1×10^{-6}	µc/g
Residential	I^{131}	$< 1.5 \times 10^{-6}$	µc/g
Eastern Washington and Oregon	I^{131}	No Samples	µc/g
Fission Products less I^{131} - Wash. and Ore.	Gamma Emitters	No Samples	µc/g

* The % MPC_w is the percent of the maximum permissible limit for occupational exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

** The % MPC_w-GI is the percent of the maximum permissible concentrations for persons in the neighborhood of controlled areas for continuous exposure to the gastrointestinal tract calculated from drinking water limits contained in NBS Handbook 69.

*** This location is now sampled quarterly. The most recent result is tabled.

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EXPOSURE EVALUATION AND RECORDS

Exposure Incidents above Permissible Limits

	Whole Body	Localized
January	0	2
1961 to Date	0	2

Gamma Pencils

	Pencils Processed	Paired Readings 100-280 mr	Paired Readings Over 280 mr	Lost Readings
January	4,978	75	3	0
1961 to Date	4,978	75	3	0

Beta-Gamma Film Badges

	Badges Processed	Readings 100-300 mrads	Readings 300-500 mrads	Readings Over 500 mrads	Lost Readings	Average Dose Per Film Packet mrad(ow)	Average Dose Per Film Packet mr(s)
January	10,630	712	65	4	16	6.45	14.82
1961 to Date	10,630	712	65	4	16	6.45	14.82

Neutron Film Badges

	Film Processed	Readings 50-100 mrem	Readings 100-300 mrem	Readings Over 300 mrem	Lost Readings
Slow Neutron					
January	2,080	0	0	0	9
1961 to Date	2,080	0	0	0	9
Fast Neutron					
January	556	108	43	0	9
1961 to Date	556	108	43	0	9

Whole Body Counter

	Male	Female	January	1961 to Date
GE Employees				
Routine	42	4	46	46
Special	8	0	8	8
Terminal	0	0	0	0
Nonemployees	4	0	4	4
Pre-employment	0	0	0	0
Total	54	4	58	58

Bioassay

	January	1961 to Date
Confirmed Plutonium Deposition Cases	1	1*
Plutonium: Samples Assayed	541	541
Results above 2.2×10^{-8} µc/sample	15	15
Fission Products: Samples Assayed	594	594
Results above 3.1×10^{-5} µc FP/sample	1	1
Uranium: Samples Assayed	263	263

*Bringing the total number of plutonium deposition cases which have occurred at Hanford to 264.

Uranium Analyses

Sample Description	Following Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples	Following Period of No Exposure Units of 10^{-9} µc U/cc Maximum	Average	Number Samples
Fuels Preparation	23.8	4.1	57	23.5	2.6	48
Fuels Preparation*	0	0	0	0	0	0
Hanford Laboratories	224.2	11.1	33	8.7	2.6	27
Hanford Laboratories*	0	0	0	0	0	0
Chemical Processing	24.7	4.5	38	12.8	3.3	38
Chemical Processing*	21.3	7.8	11	15.6	6.6	5
Special Incidents	700.0	204.4	4	0	0	0
Random	1.3	0.8	2	0	0	0

*Samples taken prior to and after a specific job during work week.

Thyroid Checks	January	1961 to Date
Checks Taken	0	0
Checks above Detection Limit	0	0
Hand Checks		
Checks Taken - Alpha	21,083	21,083
- Beta-gamma	51,795	51,795
Skin Contamination		
Plutonium	6	6
Fission Products	43	43
Uranium	22	22

CALIBRATIONS

	Number of Units Calibrated January	1961 to Date
Portable Instruments		
CP Meter	860	860
Juno	223	223
GM	755	755
Other	156	156
Audits	103	103
Total	2,097	2,097
Personnel Meters		
Badge Film	1,020	1,020
Pencils	-	-
Other	286	286
Total	1,306	1,306
Miscellaneous Special Services	656	656
Total Number of Calibrations	4,059	4,059

A R Keene
Manager
Radiation Protection

AR Keene:jmb 1234151

LABORATORY AUXILIARIES OPERATION
MONTHLY REPORT - JANUARY, 1961

GENERAL

There was one security violation charged to the Operation.

There were no major inuries; the minor injury frequency rate was 1.86, which is considerably below average experience.

TECHNICAL SHOPS OPERATION

Total productive time for the period was 17,253 hours. This includes 13,674 hours performed in the Technical Shops, 3,113 hours assigned to Minor Construction, 40 hours assigned to other project shops and 426 hours assigned to off-site vendors. Total shop backlog is 21,100 hours, of which 60% is required in the current month with the remainder distributed over a three-month period. Overtime hours worked during the month was 4.5% (837 hours) of the total available hours.

Distribution of time was as follows:

	Man-Hours	% of Total
Fuels Preparation Department	4,006	23.2
Irradiation Processing Department	867	5.0
Chemical Processing Department	586	3.4
Hanford Laboratories Operation	11,438	66.3
Miscellaneous	356	2.1

Requests for emergency service decreased, permitting an overtime rate of 4.5%, compared to 5.1% the previous period.

At the close of the reporting period, there were three open requisitions for Journeyman Machinists and one for a qualified Instrument Technician. Two candidates are in process and others are being considered.

Security performance was considered satisfactory, with no violations. There were seven medical treatment injuries, which is considered the normal level expected in an operation of this type.

RADIOGRAPHIC TESTING OPERATION

A total of 7,156 tests were made, of which 1,419 were radiographic (including x-ray, gamma-ray, and auto-radiographs) and 5,737 were supplementary tests. Out of a total of 3,757 man-hours, 1,064 (28.4%) were used in connection with radiographic tests, and 2,693 (71.6%) were used on supplementary tests.

The supplementary test work included: borescoping; dimensional measurements (air gage); eddy current; magnetic particle; penetrant (fluorescent O.D. and I.D.); surface treatment (pickling, steam detergent cleaning, and vapor degreasing); and ultrasonic (core integrity, bond tests, flaw detection, and thickness measurements).

The number of pieces handled this month totaled 6,139 items. The feet of material represented by these items amounted to 56,751 feet. Work on tubular components continued to account for a large percentage of the footage of material tested; the tubular component work includes both fuel element sheath tubes and reactor process tubes.

Work was done for 20 organizational components representing most of the operating departments and service organizations. A total of 42 reports were issued detailing test findings with conclusions and recommended action. Radiographic Testing Operation was consulted on 67 different occasions for advice and information on general testing and applications for other than the jobs tabulated in Part II Testing Statistics.

NPR process tubes are being received on a regular basis. Testing is proceeding routinely except for a problem of reproducibility of fluorescent penetrant test indications. In checking out the differences in processing and examination by the tube vendor and HAPO it has been found that the light source used by the vendor was inadequate for a thorough examination. With this condition corrected attention can now be directed to the cross-contamination that exists in the process at both sites.

A rather extensive fluorescent penetrant testing program of reactor nozzles has been started in connection with a bumper fuel element test for the B, D, DR, F and H reactors. The nozzles are being overbored, and then tested for suitability for reinstallation. Testing effort on PRTR reactor installation is still high as a result of thefinal phases of reactor construction and test operation.

The 300 Laboratory work continues at a high level with main emphasis on Zircaloy fuel element sheath tubes. Test facilities in the 314 Building are gradually being completed and should prove very helpful in expediting tube work. Included in the 314 Building work is an improved dark room facility for white and ultra-violet light borescope examination of the sheath tubes.

Testing Statistics

Component	No. of Tests	Ft. of Weld or Material	No. of Pieces
CPD	176	137	13
FPD	54	42	1
HLO	6,076	55,471	6,079
IPD	656	918	33
JA Jones	161	161	11
Kaiser Engrs.	33	22	2
Totals	7,156	56,751	6,139

CONSTRUCTION OPERATION

There were 79 existing J. A. Jones Company orders at the beginning of the month with a total unexpended balance of $130,871. Ninety new orders, 4 supplements and adjustments for underruns amounted to $169,151. Expenditures during the month on HLO work were $155,736. Total J. A. Jones backlog at month's end was $141,998.

Summary

	HL		CE&U	
	No.	Unexpended Balance	No.	Unexpended Balance
Orders outstanding beginning of Mo.	79	$ 130,871	1	$ 4,798
Issued during the Mo. (Inc.Sup.&Adj.)	90	$ 169,151		0
J.A. Jones Expenditures during Mo. (Inc.C.O. Costs)		$ 155,736		
Balance at month's end	63	$ 137,200	1	$ 4,798
Orders closed during month	106	$ 209,391*		0

*Face Value of Orders Closed

FACILITIES ENGINEERING OPERATION

The waste disposal and decontamination service for HLO became the responsibility of FEO this month. This work includes the disposal of hot liquid and dry wastes and involves the operation of the 340 Building, the 300 North burial grounds and the concreting facility in 325 Building. Four non-exempt employees are used in this Operation.

Projects

There were 14 authorized projects at month's end with total authorized funds of $2,692,000. The total estimated cost of these projects is $4,557,000. The balance between expenditures to 12-31-60, and total estimated cost is $2,006,000.

The following summarizes the status of project activity:

Number of authorized projects at month's end	14
Number of new projects authorized during the month	0
Projects completed during the month CGH-819 - Increased Laboratory Waste Facilities	1
New project proposals submitted to AEC during month	1

New projects awaiting AEC approval:

- CGH-832 Full Scale Physical Constants Test Reactor
- CGH-874 Consolidation of Plutonium Metallurgy Facilities 231-Z
- CGH-902 Uranium Scrap Burning Facility
- CGH-916 Fuels Recycle Pilot Plant
- CAH-917 Field Service Center
- CGH-918 Second Whole Body Counter Cell Addition - 747 Building
- CGH-919 314 Building Ventilation System
- CAH-921 Geological & Hydrological Wells - FY-1961

Note - Proposals complete or nearing completion are as follows:

- Spectroscopy Laboratory - 325 Building
- Irradiated Burst Test Facility
- 271-CR Waste Treatment Facility

The attached project report contains details of individual project work.

Engineering Services

Engineering work performed during the month included the following listed major items as well as scope engineering for project proposals. The availability of capital funds have increased the work load.

Title	Status
Pressure Vessel and Piping Systems - Engineering & Inspection Service	This is a continuing work program on HLO vessels, pressure systems and related safety devices. The work includes periodic inspection and engineering evaluations of plant pressure systems and engineering service to R&D components having process devices subjected to high pressures and temperatures. Code compliance engineering work is being performed on - 1) PRTR Systems; 2) Irradiation Studies Loop; 3) Breakaway Corrosion Loop; and, 4) HLO PAC & Equipment Projects. All data has been accumulated for the PRTR and has been submitted to the Third Party Inspector for review and approval.
"Split-half" Machine for Critical Mass Studies	Design of machine and safety rods nearing completion. Comment drawings have been issued.
Horizontal Control Rod and Drive for Tamper Tank (Critical Mass)	Design work is nearing completion. Materials are on order.
Basement Access Enclosure - 325 Bldg.	Construction work is complete.
Beryllium dust filters - 306 Building	Design complete. Fabrication and installation work has started.
Fuel Element Assembly Room - Basement Mezzanine, 325 Bldg.	Construction work is essentially complete.
Electrical Modifications - 3702 Bldg.	Material is on hand and field work is in progress.
Filter Changer - CWS	A new technique of filter change procedure is being developed which may reduce hazards.
327 Water Basin - Clean-up System	A study of a recirculation system for removing radioactive contaminates from storage basin water.

Title	Status
Special Air Conditioning - Laboratory in 222-U Building	Materials are on order. Field work to start during March.
Animal pens and facilities	Additional animal pens, pastures, and improvements to animal farm - 100-F.

Drafting and Design Services

Work load in central drafting room (3706) is heavy. Branch offices in 306 and 308 Buildings have steady work loads with heavy backlog in 308 office. The equivalent of 250 design drawings were completed this month.

Major design and drafting work in progress includes the following:

1. PRP Critical Facility - Detail in-cell piping, ventilation, instrumentation and electrical work (18 dwgs. - essentially complete).
2. Physical and Mechanical Properties Test Cell - 327 Building - Special equipment design (75% complete).
3. Structural Materials Irradiation Test Facility - design - 30 dwgs. required - 75% complete).
4. Strontium Purification Project - Work approximately 98% complete.
5. Thermal Precipitator - (5 dwgs. required, 40% complete).
6. Breakaway Corrosion Loop -(Approximately 90% complete).
7. Critical Facility - Approximately 20 dwgs. required - estimated 55% complete.
8. Fuels Recycle Pilot Plant - conceptual work in progress.
9. Length Measurement Telescope - Complete.
10. Test Loop for 305 Bldg. Reactor - preliminary work started.
11. Ultrasonic Transducer - Bridge & Track - 4 dwgs. - 95% complete.
12. Special Air Operated Chuck for vibratory compactor - work 50% complete.
13. Oxide Press - Hood Enclosure - 75% complete.
14. Process Calciner - 7 dwgs. required - 20% complete.

Plant Maintenance and Operation

Costs for December were $149,267 which is 96.4% of forecast.

Analysis of Costs

Expenditures are 3.6% below forecast. Of this $27,000 - $8,000 is attributable to a short billing of janitor services, $3,000 to mild weather use of steam, and $16,000 to less maintenance than expected. This lower maintenance cost is attributable to the highly competitive market for maintenance work. The available work exceeded the capacity of the maintenance forces.

Improved Maintenance

Item	December
Relocation and alteration	$ 7,939
Painting	3,265
Reroofing	8,952
Electrical modifications	280
Piping modifications	98
	$ 20,534

Miscellaneous

Approximately 26,000 square feet of prints were reproduced during the month.

The total estimated value of the 20 requisitions issued during the month was $16,000. The majority of this procurement activity is for approved HLO projects.

Painting of 321 Building continues and painting started in 325 Building.

Plans have been made for a new drafting room location in 306 Building.

A new water still was installed in 325 Building.

Improvements are being made to the demineralizers in 308 Building.

A new product assembly room is being installed on the mezannine of 325 Building basement.

The crane in 314 Building was inspected. The crane is out of service until repairs are made.

Replacement laboratory hoods and furniture costing about $12,000 have been ordered.

Study of noise attenuation for 325 Building Conference Room is being made. A plan is being formulated for a microfilm viewer room in 3760 Building.

TECHNICAL INFORMATION OPERATION

The 1960 annual inventory of Secret Research and Development reports and of Weapon Data reports was started January 3 and completed January 24 in record breaking time. Results of the inventory are as follows: 10,196 accountable copies of which 1,049 are Weapon Data reports and 9,147 are R & D reports; 29 copies unaccounted for from previous years, none unaccounted for this year, or a total of 29 copies outstanding.

New criteria for classifying production reactor plutonium were distributed to the field via HW-68114 entitled "Classification: Plutonium" dated January 12, 1961. In this connection, the Director of the AEC's Division of Classification visited Hanford January 31 and February 1 to discuss the plutonium classification problem and its affect on the PRTR and other unclassified programs.

Declassification review of the early 3-series of Hanford documents has been completed. The classification on approximately 480 of the documents has been retained. The remainder of the nearly 5,000 documents has either been declassified or, in the case of those having no future reference value, destroyed.

During the month it became necessary to take drastic action to reduce a backlog of 23 formal reports that had accumulated in 300 Area Duplicating due to the breakdown of their stapling machine. A factory man was brought over from Seattle to repair the machine; some backlogged reports were sent for stapling to the 700 Area Printing and Duplicating, and some were sent off-project to the Tri-City Herald. The latter -- 1,258 copies --- were stapled for only $19.72, a very low price. By month's end the backlog had been eliminated.

Agreement has been reached with CE&UO for the Classified Files messengers to take over the delivery and pickup of classified engineering drawings being routed from the Engineering Files. A simplified procedure with a minimum of record keeping is being worked out. Total deliveries involved are about 100 per month.

The detailed specifications for the Flexowriters to be used in the Files automation program were worked out and the machines ordered by the Specialist, Office Equipment, CE&U. To assure compatability between the Flexowriters and the IBM equipment, representatives of both companies and the Technical Information Operation met to work out the details. The 6 channel Flexowriter presently used by Technical Information for the production of catalog cards, will be converted for use elsewhere on the Plant. The forms for use in the automation program have been ordered.

The periodical automation program is essentially completed and the system "debugged". Sample lists and reports have been printed from the tape and subscription renewals are being handled with cards printed from taped information.

Work Volume Statistics

Document Distribution and Files	December	January
Documents routed and discharged (copies)	18,401	18,701
Documents issued (copies)	7,582	18,181
Documents sent off-site (copies)	1,777	10,489
Document reserves filled (copies)	596	640
Documents picked up and delivered	17,684	21,015

	December	January
Document Accountability		
Holders of classified documents whose files were inventoried	426	640
Documents inventoried in Files (copies)	--	10,196
Documents destroyed or retired (copies)	10,931	9,220
Documents revised (copies)	1,466	1,300
Documents pulled and documents filed (copies)	15,013	16,960
Documents reclassified	527	823
Documents microfilmed	4,856	3,169
Accountable copies of SECRET and CONFIDENTIAL documents on-site	209,601	209,751
Reference and Publication		
Books cataloged (new titles)	44	124
Books added to the collection (volumes)	135	236
Ready reference questions answered by professional staff	202	210
Literature searches by professional staff	84	88
Reports abstracted (titles)	230	288
Formal reports prepared (titles)	7	21
Off-site requests for HAPO reports (copies)	270	279
Reports released to CAP (titles)	28	31
Library Acquisitions and Circulation		
Books ordered (volumes)	363	645
Periodicals ordered	1,516	124
Books circulated (volumes)	1,663	1,512
Periodicals circulated (issues)	3,594	2,749
Inter-Library loans	70	74
Films borrowed or rented	15	13
Industrial film showings	57	50
Bound periodicals added to the collection	180	144

Library Collection

	Main Library	W-10 Library	108-F Library	Ind. Med.	Total
No. of books	30,760	8,569	1,723	2,029	43,081
No. of bound periodicals	14,146	10	1,868	1	16,025
	44,906	8,579	3,591	2,030	59,445

Classification and Declassification

	December	January
Documents, including drawings and photographs reviewed for downgrading or declassification	359	440
Documents and papers (intended for oral presentation or publication) reviewed for appropriate classification	11	33
Documents submitted to Declassification Branch, Oak Ridge	1	81

J. L. Boyd

Manager,
Laboratory Auxiliaries

JL Boyd:jw

SEMI-MONTHLY PROJECT STATUS REPORT
HANFORD LABORATORIES OPERATION

HW- 63350
DATE January 31, 1961

PROJ. NO.	TITLE	FUNDING
CA-744	Metallurgical Development Facility - 306 Building Addition	58-b-4

AUTHORIZED FUNDS				
$ 2,685,000	DESIGN $ 137,200	AEC $ 1,366,000	COMMIT'D TO 10-30-60	$ 2,581,449
	CONST. $ 2,547,000	GE $ 1,319,000	ESTIMATED TOTAL COST	$ 2,670,000

STARTING DATES		DIRECT COMPL. DATES		EST'D COMPL DATES	
	DESIGN 6-30-58		DESIGN - -		DESIGN 9-30-59
	CONST. 3-20-59		CONST. 9-1-60		CONST. 9-1-60

ENGINEER

FEO - KA Clark Project Engineer - J. T. Hall

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		10,600
COST PLUS FIXED FEE		2,500
PLANT FORCES		500
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		260
GE FIELD ENGINEER		425

PERCENT COMPLETE			
	EST'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE	100	100	100
CONST.	100	100	100
PP	2	100	100
CPFF	42	100	100
FP	56	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide increased capacity for an expanding reactor fuels research and development program, and involves an addition to the 306 Building.

The only exception to completion which has not been resolved is the correction of preheat coil controls. This will be done in April. Startup items of work are nearing completion. This report concludes the routine reporting of this project.

PROJ. NO.	TITLE	FUNDING
CGH-805	High Temperature Tensile Testing Cell - 327 Building	0290

[redacted]

SEMI-MONTHLY PROJECT STATUS REPORT
HANFORD LABORATORIES OPERATION

HW- [illegible]
DATE 1-31-61

PROJ. NO.	TITLE	FUNDING
CG-785	In-Reactor Studies Equipment - 105 KW	0290

AUTHORIZED FUNDS				
$ 325,000	DESIGN $ 44,000	AEC $ - -	COMMIT'S. TO 1-15-61	$ 275,143
	CONST. $ 281,000	GE $ 325,000	ESTIMATED TOTAL COST	$ 315,000

STARTING DATES	DESIGN. 1-5-59	DIRECT COMPL. DATES	DESIGN -	EST'D. COMPL. DATES	DESIGN 12-30-60
	CONST. 3-22-60		CONST. 3-1-61		CONST. 3-1-61

ENGINEER
FEO - H. Radow

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES	1	1150
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	0	710
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE	100	100	100
CONST.	100	98	98
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a research and development facility to permit instantaneous measurement of physical properties of materials under dynamic in-reactor and simultaneous ex-reactor conditions.

All of the procurement items for the helium conservation modification have not yet been received; however, this has caused no delay in test studies with the R&D capsule now in the reactor.

PROJ. NO.	TITLE	FUNDING
CGH-819	Increased Laboratory Waste Facilities - 300 Area	60 - 1

AUTHORIZED FUNDS				
$ 193,765	DESIGN $ 27,000	AEC $ -	COMMIT'S. TO 1-15-61	$ 135,684
	CONST. $ 166,675	GE $ 193,675	ESTIMATED TOTAL COST	$ 155,000

STARTING DATES	DESIGN. 7-30-59	DIRECT COMPL. DATES	DESIGN - -	EST'D. COMPL. DATES	DESIGN 4-29-60
	CONST. 6-8-60		CONST. 5-31-61		CONST. 5-31-61

ENGINEER
FEO - K. A. Clark

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		380
COST PLUS FIXED FEE	6	590
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		400
GE FIELD ENGINEER	.5	44

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE	100	100	100
CONST.	100	100	100
PF	4	100	100
CPFF	30	100	100
FP	66	100	100

SCOPE, PURPOSE, STATUS & PROGRESS

This project will increase the contaminated liquid waste handling facility in the 300 Area, and involves greater storage capacity and improved loadout accommodations.

Construction is complete with the exception of items requiring modification because of inadequate facilities.

Design changes have been made to include a spare transfer pump and supplemental loadout piping so that every pump has a spare.

The project is being closed out with accruals for the exceptions to construction completion.

1234163

SEMI-MONTHLY PROJECT STATUS REPORT

HANFORD LABORATORIES OPERATION

DW 68350

DATE 1-31-61

PROJ. NO.	TITLE	FUNDING
CAH-822	Pressurized Gas Cooled Facility	+141 - Operating

AUTHORIZED FUNDS				
$ 995,000	DESIGN $ 40,000* / CONST. $ 955,000	AEC $ - / GE $ 995,000	COMMIT'S. TO 1-1-61	$ 915,932
			ESTIMATED TOTAL COST	$ 1,120,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
DESIGN.	8-19-59	DESIGN	--	DESIGN	4-29-60
CONST.	10-17-60	CONST.	6-30-61	CONST.	9-30-61

ENGINEER

HLO - DP Schively

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE	Head Mechanical	
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE	100	100	100
CONST.	100	65	60
PF			
CPFF	32	NS	NS
FP	68	100	95

SCOPE, PURPOSE, STATUS & PROGRESS

*Does not include design performed by Struthers-Wells.

Work by Head Mechanical (J. A. Jones sub-contract, JAJ-73) stopped temporarily for installation of the Struthers-Wells packages. The fixed price work will be complete after installation of the packages.

PROJ. NO.	TITLE	FUNDING
CGH-834	Modifications & Additions to High Pressure Heat Transfer/ Apparatus (189-D Bldg.)	0290

AUTHORIZED FUNDS				
$ 700,000	DESIGN $ 66,000 / CONST. $ 634,000	AEC $ - / GE $700,000	COMMIT'S. TO 1-15-61	$ 675,213
			ESTIMATED TOTAL COST	$ 700,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
DESIGN.	4-20-59	DESIGN		DESIGN	2-15-61
CONST.	4-22-59	CONST.	4-1-61	CONST.	4-1-61

ENGINEER

FEO - H. Radow

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	0	3150
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION	.5	960
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	99
AE			
GE	100	100	99
CONST.	100	93	93
PF			
CPFF	100	93	93
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides necessary modifications to existing equipment to simulate more severe in-reactor operating conditions in out-of-reactor facilities for research and development studies.

The air receivers are enroute from Chicago Bridge & Iron Company and receipt on site is anticipated by the end of this reporting period. Work in the field will then be resumed. Indicated shipment of the water storage vessels by Struthers-Wells is now mid-February. Progress on the high-speed valve order is favorable.

1234164

SEMI-MONTHLY PROJECT STATUS REPORT

HANFORD LABORATORIES OPERATION

DATE 1-31-61

PROJECT CAH-842

TITLE: Critical Reactivity Measuring Facility

FUNDING: 58-e-15

AUTHORIZED FUNDS					
$ 360,000	DESIGN $ 45,000	AEC $ 148,000	COMMIT'S. TO 1-1-61	$ 84,659
	CONST. $ 315,000	GE $ 212,000	ESTIMATED TOTAL COST	$ 360,000

STARTING DATES	DESIGN. 11-17-59	DIRECT COMPL. DATES	DESIGN --	EST'D. COMPL. DATES	DESIGN 11-18-60
	CONST. 10-3-60		CONST. 4-30-61		CONST. 4-30-61

ENGINEER: HLO - WS Kelly

MANPOWER

	AVERAGE	ACCUM. MANDAYS
FIXED PRICE	Geo. Grant Company, Inc.	
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE

	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE			
CONST.	100	NS	20
PF			
CPFF			
FP	80	62	25

SCOPE, PURPOSE, STATUS & PROGRESS

Orders have been placed for the reactor assembly and moderator storage tank.

PROJECT CAH-866

TITLE: Shielded Analytical Laboratory - 325 B Building

FUNDING: 61-a-1

AUTHORIZED FUNDS					
$ 60,000	DESIGN $ 60,000	AEC $ 45,000	COMMIT'S. TO 1-15-61	$ 15,000 (G.E.)
	CONST. $	GE $ 15,000	ESTIMATED TOTAL COST	$ 700,000

STARTING DATES	DESIGN. 9-5-59	DIRECT COMPL. DATES	DESIGN 11-30-60	EST'D. COMPL. DATES	DESIGN 11-14-60
	CONST.		CONST.		CONST. 3-1-62

ENGINEER: FEC - RW Dasenzo

MANPOWER

	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE

	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE	90	100	100
GE	10	100	100
CONST.	100	NS	0
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow greater capacity for analytical work involving today's more highly radioactive solutions and consists of adding a shielded laboratory to the 325 Building.

The revised project proposal for total construction funds was sent to AEC for approval on 12-28-60.

1234165

SEMI – MONTHLY PROJECT STATUS REPORT
HANFORD LABORATORIES OPERATION

HW- 68359
DATE January 31, 1961

PROJ. NO.	TITLE	FUNDING
CGH-857	Physical and Mechanical Properties Testing Cell-327 Bldg.	0290

AUTHORIZED FUNDS					
$ 75,000	DESIGN $ 75,000 / CONST. $ -	AEC $ - - / GE $ 75,000	COMMIT'S. TO 1-15-61	$ 74,998	
			ESTIMATED TOTAL COST	$ 500,000	

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN 10-29-59 / CONST. --		DESIGN -- / CONST. --		DESIGN 3-1-61 / CONST. 7-1-63

ENGINEER
FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM-MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER	1	
DESIGN ENGINEERING OPERATION	1	
GE FIELD ENGINEER		

PERCENT COMPLETE			
	WT'D.	SCHED.	ACTUAL
DESIGN	100	95*	94
A&HLO	25	96	93
GE			
CE&UO	75	95	94
CONST.	100	NS	--
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities for determining physical and mechanical properties of irradiated materials, and involves the installation of a cell in 327 Building. The design status is as follows:

1. HLO Equipment Design.
   The status is the same as the last report as the comments on the detail drawings for the HLO designed equipment are not completed.

2. CE&UO Equipment Design. (Other than service or utility) Bovay & Co.
   A. Annealing Furnace - Engineering work sheet was approved; details are to be made.
   B. Electrical Resistivity Furnace - Engineering work sheet was approved; details are to be made.
   C. Dilatometer Machine - Engineering work sketches were reviewed and new engineering sketches will be made.

3. CE&UO Cell and Ancillary Design.
   All drawings have been checked and will be reviewed once more after equipment design is completed.

*A revised schedule has been submitted to AEC for approval.

SEMI – MONTHLY PROJECT STATUS REPORT
HANFORD LABORATORIES OPERATION

HW- 68350
DATE 1-31-61

PROJ. NO.	TITLE	FUNDING
CGH-858	High Level Utility Cell - 327 Building	0290

AUTHORIZED FUNDS				
$ 70,000	DESIGN $ 70,000	AEC $ --	COMMIT'S. TO 1-15-61	$ 70,000
	CONST. $ - -	GE $ 70,000	ESTIMATED TOTAL COST	$ 500,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN 10-29-50		DESIGN		DESIGN 2-15-60
	CONST.		CONST.		CONST. 8-1-63

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM-MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT - ENGINEER	2	
DESIGN ENGINEERING OPERATION	4	
GE FIELD ENGINEER		

	PERCENT COMPLETE		
	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	96
HLO	45	100	96
CE&UO	50	100	96
GE Vendor	5	100	100
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities to prepare specimens from irradiated materials for use in determining their physical and mechanical properties and involves the installation of a cell in 327 Building.

The design status is as follows:

1. HLO Equipment Design

   a. Metal Slitting Machine - Checked and comments being incorporated.

   b. Flat Tensile Sampler Former Machine - Ready for approval.

   c. Round Tensile Sampler Former Machine - Assembly drawings commented upon, being detailed.

2. CE&UO Cell and Ancillary Equipment Design

   Work on checking is continuing.

3. Western Gear Vendor Design

   Metal Decladder Machine - Western Gear reproducible drawings and specifications were received on 1-18-61 and are being reviewed.

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SEMI – MONTHLY PROJECT STATUS REPORT

HANFORD LABORATORIES OPERATION

HW- 68350

DATE 1-31-61

PROJ. NO.	TITLE	FUNDING
CAH-870	Facility for Recovery of Radioactive Materials - 325 Bldg.	60-a-1

AUTHORIZED FUNDS				
$ 486,000	DESIGN $ 46,000 / CONST. $ 440,000	AEC $ 446,000 / GE $ 40,000	COMMIT'S. TO 1-15-61	$ 39,219 (G.E.)
			ESTIMATED TOTAL COST	$ 486,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
DESIGN. 11-20-59	CONST. 5-6-60	DESIGN –	CONST. 6-1-61	DESIGN 3-1-60	CONST. 6-1-61

ENGINEER

FEO - RW Dascenzo

MANPOWER	AVERAGE	ACCUM-MANDAYS
FIXED PRICE	14	2808
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT – ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER	2	

PERCENT COMPLETE			
	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE	90	100	100
GE	10	100	100
CONST.	100	87	88
PF	1	100	100
CPFF			
FP	99	85	88

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a facility for recovery of specific radioisotopes from wastes, and involves an addition to 325 Building.

Work completed in the last two weeks is as follows:

1. Completed grinding, patching and finishing concrete on cover slabs for all vaults and trench by contractor (not approved by G.E).

2. Completed finishing concrete walls inside Vault "C". Three (3) tanks were set in vault.

3. Working on finishing of concrete walls in Vault "B".

4. Part of the cover slabs were set on Vaults "A" and "C". Two did not fit too good.

5. Hanford Piping completed remodeling of dip legs for Vault "A". They are working on installation of instrumentation and piping in trench and vaults.

6. All the filter boxes and associated duct work have been installed and require minor adjustments. Tie-in of the exhaust duct to plenum chamber is scheduled for January 28, 1961.

7. All protective coatings have been placed on walls and fixtures of the pipe trench. The painters acid-etched the inside siding and bottom of roof deck and then painted it one prime and seal coat.

8. The sprinkler system piping has been installed and partially tested.

9. Power City Electrical subcontractor is installing the electrical lines in Vault "A".

SEMI-MONTHLY PROJECT STATUS REPORT

HANFORD LABORATORIES OPERATION

HW- [illegible]

DATE 1-31-61

PROJ. NO.	TITLE	FUNDING
CAH-885	Geological and Hydrological Wells - FY-60	60-1

AUTHORIZED FUNDS				
$ 69,000	DESIGN $ 1,000 / CONST. $ 68,000	AEC $ 59,900 / GE $ 9,100	COMMIT'S. TO	$ 9,069 (3)
			ESTIMATED TOTAL COST	$ 69,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
DESIGN.	2-15-60	DESIGN		DESIGN	3-9-60
CONST.	3-8-60	CONST.	3-15-61	CONST.	2-15-61

ENGINEER

FEO - HE Ralph

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE			
CONST.	100	98	98
PF	15	100	100
CPFF			
FP	85	98	98

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves the continued drilling of exploratory type wells used in determining the conditions of water tables within Hanford Works.

Ten (10) of the eleven (11) wells on this project have been completed for a total of 4,500 ft. of hole.

Contractor is on schedule. Present indications are that construction work will be completed ten (10) days ahead of schedule.

PROJ. NO.	TITLE	FUNDING
CAH-888	Biology Laboratory Improvements	60-A-1

AUTHORIZED FUNDS				
$	DESIGN $ / CONST. $	AEC $ / GE $	COMMIT'S. TO	$
			ESTIMATED TOTAL COST	$ 420,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
DESIGN.		DESIGN		DESIGN	
CONST.		CONST.		CONST.	

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	NS	[illegible]
AE	83	NS	84
GE	17	NS	100
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

B. D. Bohna have tentatively altered completion of design to March 1, 1961. A summary of considerable extra design time has been submitted by B. D. Bohna for overhead costs pending notification to proceed after stoppage resulting from more design work than expected for irradiation facility and various changes to design. This request is being evaluated. In addition to the above, the A.E. recommends they be assigned the task of preparing shop drawings and specifications for shop fabrication.

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SEMI-MONTHLY PROJECT STATUS REPORT
HANFORD LABORATORIES OPERATION

HW [illegible]
DATE 1-31-61

PROJ. NO.	TITLE	FUNDING
CAH-867	Fuel Element Rupture Test Loop	58-e-15

AUTHORIZED FUNDS				
$ 1,500,000	DESIGN $ 130,000 / CONST. $ 1,370,000	AEC $ 770,000 / GE $ 730,00	COMMIT'S. TO 1-22-61	$ 324,067
			ESTIMATED TOTAL COST	$ 1,500,00

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
DESIGN	8-1-60*	DESIGN	-	DESIGN	2-1-61
CONST.	11-2-60	CONST.	10-31-61	CONST.	10-31-61

ENGINEER: HLO - PC Walkup

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE -- G. A. Grant Co., Inc.		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN	100	100	99
AE	9	100	100
GE	91	100	99
CONST.	100	2	5
PF	34		
CPFF	11		
FP	55	58**	58

SCOPE, PURPOSE, STATUS & PROGRESS

* Detail design. Scope design started 11/2/59 and completed 3/15/60.

** Rupture Facility Schedule received from G. A. Grant Co., Inc., on 1/5/61.

PROJ. NO.	TITLE	FUNDING
CGH-874	Consolidation of Plutonium Metallurgy Facilities-231-Z	61-j

AUTHORIZED FUNDS				
$	DESIGN $ / CONST. $	AEC $ / GE $	COMMIT'S. TO	$
			ESTIMATED TOTAL COST	$ 297,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
DESIGN.	1*	DESIGN		DESIGN	
CONST.	2*	CONST.		CONST.	

ENGINEER: FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU.
DESIGN			
AE			
GE			
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides in one location facilities devoted to plutonium metallurgy research and development activities. This will result in more efficient utilization of space and personnel.

The revised project proposal was placed on the AEC agenda for review on January 27, 1961.

* Months after authorization.

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SEMI-MONTHLY PROJECT STATUS REPORT

HANFORD LABORATORIES OPERATION

HW [illegible]

DATE 1-31-61

PROJ. NO.	TITLE	FUNDING
CAH-896	Stress Rupture Test Facility	60-1

AUTHORIZED FUNDS				
$ 80,000	DESIGN $ 7500 / CONST. $ -	AEC $ 69,000 / GE $ 11,000	COMMIT'S. TO 11-15-61	$ 7421
			ESTIMATED TOTAL COST	$ 80,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL DATES	
DESIGN.	7-29-60	DESIGN	-	DESIGN	12-1-60
CONST.	2-2-60	CONST.	10-15-61	CONST.	10-15-61

ENGINEER

FEO - RK Waldman

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	100	100
AE			
GE	100	100	100
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project involves a facility for deliberately rupturing tubing to establish service conditions.

Bid review is scheduled for February 2, 1961.

PROJ. NO.	TITLE	FUNDING
CAH-901	Structural Materials Irradiation Test Equipment - ETR	0290

AUTHORIZED FUNDS				
$ 125,000	DESIGN $ 15,000 / CONST. $ 110,000	AEC $ 21,000 / GE $ 104,000	COMMIT'S. TO 1-15-61	$ 42,059
			ESTIMATED TOTAL COST	$ 125,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL DATES	
DESIGN.	9-15-60	DESIGN	2-15-61	DESIGN	[illegible]
CONST.		CONST.	10-15-61	CONST.	10-15-61

ENGINEER

FEO - K. A. Clark

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING ~~OPERATION~~	2	100
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN	100	97	85
AE			
GE	100	97	85
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides for the installation of equipment at the ETR for which changes in the physical properties of reactor structural materials subjected to in-reactor conditions can be determined.

Design completion is being delayed to incorporate comments from the Phillips Petroleum Company which will result in improved maintenance features.

Installation of sub-pile piping is expected to be started during the month of February.

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SEMI-MONTHLY PROJECT STATUS REPORT
HANFORD LABORATORIES OPERATION

HW
DATE 1-31-61

PROJ. NO.	TITLE	FUNDING
CGH-902	Uranium Scrap Burning Facility	61-j

AUTHORIZED FUNDS				
$ 36,000	DESIGN $	AEC $	COMMIT'S. TO	$
	CONST. $	GE $	ESTIMATED TOTAL COST	$ 36,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN. 2*		DESIGN		DESIGN
	CONST. 6*		CONST.		CONST.

ENGINEER
FEO - R. K. Waldman

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUA
DESIGN			
AE			
GE			
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project provides a means of making uranium scrap material safer for storage and off-plant shipment by converting this scrap to a stable uranium oxide. The facility will be adjacent to the 333 Building.

Directive and work authority has been received but no work was started until review by General Electric Company has been made regarding AEC's proposed change of Method of Performing Work.

* Weeks after authorization.

PROJ. NO.	TITLE	FUNDING
CGH-907	Strontium 90 Interim Program	75% Operating 25% - 0290

AUTHORIZED FUNDS				
$ 420,000	DESIGN $ 35,000	AEC $ --	COMMIT'S. TO 1-15-61	$ 394,751
	CONST. $ 385,000	GE $420,000	ESTIMATED TOTAL COST	$ 420,000

STARTING DATES		DIRECT COMPL. DATES		EST'D. COMPL. DATES	
	DESIGN 9-8-60		DESIGN		DESIGN 3-1-61
	CONST. 9-8-60		CONST. 3-1-61		CONST. 3-1-61

ENGINEER
FEO - H. Radow

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE	33	2800
PLANT FORCES	2	100
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN	100	97	98
AE			
GE	100	97	98
CONST.	100	80	80
PF	11	80	80
CPFF	89	80	80
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will allow the separation of Strontium-90 material from Separations Plant waste streams on an interim basis, and involves the conversion of the Hot Semi-Works Plant for this purpose.

Punch list items on "A" and "C" cells are nearing completion. It is anticipated that "B" cell will be accepted, with exceptions, by the end of this reporting period. Work on the outside lines is progressing favorably and detail design of the loadout station is in the final stages.

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SEMI-MONTHLY PROJECT STATUS REPORT

HANFORD LABORATORIES OPERATION

HW

DATE 1-31-61

PROJ. NO.	TITLE	FUNDING
CAH-914	Rattlesnake Springs Radioecology Facility	61-1

AUTHORIZED FUNDS				
$ 72,000	DESIGN $ 3400* / CONST. $ 68,600	AEC $ 53,700 / GE $ 18,300	COMMIT'D.	$
			ESTIMATED TOTAL COST	$ 72,000

STARTING DATES	DESIGN. 2-1-61 / CONST. 3-15-61	DIRECT COMPL. DATES	DESIGN / CONST 10-31-61	EST'D. COMPL. DATES	DESIGN 4-1-61 / CONST 10-31-61

ENGINEER

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN			

SEMI-MONTHLY PROJECT STATUS REPORT

HANFORD LABORATORIES OPERATION

DATE 1-31-61

PROJ. NO.	TITLE	FUNDING
CAH-917	Field Service Center - Atmospheric Physics	61-j

AUTHORIZED FUNDS $	DESIGN $	AEC $	COMMIT'S. TO $
	CONST. $	GE $	ESTIMATED TOTAL COST $ 154,000

STARTING DATES	DESIGN. 1*	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN 4*
	CONST. 2*		CONST.		CONST. 9*

ENGINEER

FEO - JT Lloyd

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN			
AE			
GE			
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide facilities necessary to conduct atmospheric physics research and development programs.

The revised project proposal was transmitted to the AEC on January 23, 1961. It will probably be placed on the AEC Agenda of February 2, 1961.

* Months after authorization.

PROJ. NO.	TITLE	FUNDING
CGH-918	Second Whole Body Counter - Cell Addition - 747 Building	61 - j

AUTHORIZED FUNDS $	DESIGN $	AEC $	COMMIT'S. TO $
	CONST. $	GE $	ESTIMATED TOTAL COST $ 110,000

STARTING DATES	DESIGN. 1*	DIRECT COMPL. DATES	DESIGN	EST'D. COMPL. DATES	DESIGN 4*
	CONST. 8*		CONST.		CONST. 16*

ENGINEER

FEO - KA Clark

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTU
DESIGN			
AE			
GE			
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will provide a second whole body monitoring cell in the 747-A Building to increase the capacity of the Whole Body Counter Facility to meet projected needs.

The project proposal is being studied by the AEC.

* Months after authorization.

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SEMI-MONTHLY PROJECT STATUS REPORT

HANFORD LABORATORIES OPERATION

DATE 1-31-61

FUNDING 61 - J

PROJ. NO.	TITLE
CGH-919	Air Conditioning - 314 Building

AUTHORIZED FUNDS $	DESIGN $	CONST. $	AEC $	GE $	COMMIT'S. TO $	ESTIMATED TOTAL COST $
						27,000

STARTING DATES	DESIGN.	CONST.	DIRECT COMPL. DATES	DESIGN	CONST.	EST'D. COMPL. DATES	DESIGN	CONST.
	1/2*	3-1/2*					2-1/2*	5-1/2*

ENGINEER

FEO - KR Waldman

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN			
AE			
GE			
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

This project will supplement existing cooling units, thus providing cooling air supply commensurate with heat load and outdoor temperatures.

The project proposal was submitted to HOO-AEC, 12-21-60.

* Months after authorization.

PROJ. NO.	TITLE	FUNDING

AUTHORIZED FUNDS $	DESIGN $	CONST. $	AEC $	GE $	COMMIT'S. TO $	ESTIMATED TOTAL COST $

STARTING DATES	DESIGN.	CONST.	DIRECT COMPL. DATES	DESIGN	CONST.	EST'D. COMPL. DATES	DESIGN	CONST.

ENGINEER

MANPOWER	AVERAGE	ACCUM. MANDAYS
FIXED PRICE		
COST PLUS FIXED FEE		
PLANT FORCES		
ARCHITECT-ENGINEER		
DESIGN ENGINEERING OPERATION		
GE FIELD ENGINEER		

PERCENT COMPLETE	WT'D.	SCHED.	ACTUAL
DESIGN			
AE			
GE			
CONST.			
PF			
CPFF			
FP			

SCOPE, PURPOSE, STATUS & PROGRESS

PROFESSIONAL PLACEMENT AND RELATIONS PRACTICES OPERATION

MONTHLY REPORT

GENERAL

As of January 31, 1961 the staff of the Hanford Laboratories totalled 1382 employees, including 654 exempt and 728 weekly salaried. Of the total 562 possess technical degrees, including 333 B.S., 124 M.S., and 105 Ph.D.

HEALTH, SAFETY AND SECURITY

The medical treatment frequency for January was 1.41 as compared with 1.32 for the preceding month. There were no disabling injuries or serious accidents during the month. There was 1 security violation during the month, as compared with 2 for the corresponding period last year.

PROFESSIONAL PLACEMENT

To date, 43 offers were extended to BS/MS candidates for the Technical Graduate Program. Of these, 7 acceptances and 7 rejections have been received.

Ph.D. employment activity included 8 interviews, with 2 offers extended (Chemists-HL), one acceptance (Chemist-HL) and 4 rejections (Chemists-HL).

To date, 7 professors have accepted HAPO offers to participate in the Summer Employment Program.

EMPLOYMENT

Open requisitions at the beginning of the month totalled 23. There were 10 new requisitions received, 14 vacancies filled, and 2 cancelled.

COMMUNICATIONS

Two new recruiting brochures, "General Electric at Hanford," and "Living in the Tri-City Area," were prepared and are now in use in our recruiting activities.

TRAINING

Course or Seminar	Number of People	Status
PBM-I	41	Continuing
Creative Approach	10	Continuing
Technical Report Writing	7	Continuing

for O. E. Boston, Manager
Professional Placement
and Relations Practices

OEB:lmh

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TABLE II NONEXEMPT EMPLOYMENT

Nonexempt Employment Status	Dec.	Jan.
Requisitions		
At end of month	23	17
Cancelled	1	2
Received	14	10
Filled	14	14

Nonexempt Transfer Request	Dec.	Jan.
Transfers		
Active Cases at end of mo.	81	74
Cancelled	0	3
New	1	2
Effected	0	6

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TABLE III. PROFESSIONAL PERSONNEL PLACEMENT

A. Technical Recruiting Activity - HAPO - September 1, 1960 to Date

	Cases Considered	Visits to Richland: Invited	Visited	To Visit	Offers: Offered	Accepted	Open	On the Roll
PhD	412	117	20	42	15	3	1	2
Exp. BS/MS	156	34	24	2	24	13	6	5
Prog. BS/MS	160	-	-	-	43	7	29	4

B. Technical Recruiting Activity - HLO - September 1, 1960 to Date

	Cases Considered	Invited	Visited	To Visit	Offered	Accepted	Open	On the Roll
PhD	412	117	20	42	10	3	-	2
Exp. BS/MS	-	16	11	-	6	3	-	-

In addition to the above activity, 8 exempt employees have transferred into HLO from other HAPO departments and 7 technical graduates have accepted off-program placement in HLO to date.

C - Technical Graduate Program
Month ending January 31, 1961

Number Personnel on assignment	63
(HAPO Tech Grad Program 55	
(Western District E.P. 8	
Distribution of Assignments by Departments	
IPD	26
HLO	22
FPD	8
CPD	3
CE&UO	3
C&AO	1
Distribution of Assignments by Function	
R&D or Engineering	42
Other	21

FINANCIAL OPERATION MONTHLY REPORT
JANUARY 1961

Personnel

There were no personnel changes during the month of January.

Activities

GENERAL ACCOUNTING

Hanford Laboratories travel through January 1961, is at essentially the same level experienced during the same period in FY 1960. During the period of July through January in 1960, 700 trips were started as compared with 727 in FY 1961.

All funds available to Hanford Laboratories for off-site courses and seminars have been committed as of this date.

A complete revision to Hanford Laboratories' Manual on authorization and performance of work is nearing completion and should be published within the next few weeks. Hanford Laboratories' OPG's covering functions and responsibilities of the various sections are under review and revisions should be issued in the near future.

A report of results was issued for the physical inventory of movable cataloged equipment in the custody of Physics and Instrument Research and Development Operation. One thousand nine hundred and forty items were physically counted valued at $1,238,395, representing an increase of one hundred and sixteen items valued at $271,721 over the FY 1960 inventory.

A special report - Annual Industrial Fire Program and Experience was prepared showing the replacement value of plant and equipment assigned to HLO, excluding underground installations and open sided structures at December 31, 1960. The replacement value of plant and equipment on HLO records is $62,088,363 compared to $55,234,838 actual recorded book value. The index used in reflecting replacement value was taken from the Building Cost Index published by Smith, Henckman, and Grylls.

A report of results was issued for the quarterly physical inventory of Other Special Materials. Only minor quantity variances were detected from the inventory results submitted. To simplify future material holders quarterly inventory reporting and to reduce our reconciliation efforts we propose going to a certification type inventory effective with the March quarterly inventory. We feel this type of inventory will reduce our efforts by one half. It was evident from the inventory results that the number of material holders are declining, while the quantities in the Laboratory Equipment and Special Materials Pool are increasing. This inventory prompted five holders to transfer all or part of their material to the Pool. As more material holders accept this service which we are prepared to provide for them, future inventories will not be nearly as time consuming as they currently are.

A call letter was issued to SS material custodians to submit their material forecasts for Diversions Inside Production Channels for the fourth quarter of FY 1961 and the first and second quarter of FY 1962. In general, this means material in activities remaining within production channels but diverted from the normal flow or process stream either for development or for direct production use. We were also notified that these forecasts are now on a semi-annual basis instead of each quarter for both Inside and Outside requirements. This will eliminate a total of four forecasts annually.

A meeting was held with interested personnel from CAO and HLO for the purpose of discussing the handling of transactions pertaining to Heavy Water to enable an even flow of charges to Cost. It was agreed that:

1. Heavy Water held for return to SROO will be held in a special account, to be established by CAO, until sufficient quantities are accumulated for shipment. Transfers to this account will be accomplished monthly at salvage values furnished us by SROO and the difference billed to Operating Cost.

2. Consumption of Heavy Water will be charged to Operating Cost on a monthly basis.

3. A monthly inventory of Heavy Water will be furnished Financial to enable us to determine consumption and quantity of material (with percentage of D_2O) being accumulated for shipment to SROO.

Project unitization reports were issued during the month on the following projects:

CAH-827	Automatic Columbia River Monitoring Station, 3614 A Building	$ 34 878
CAH-837	Animal Pens, Isolation and Examination Facilities, Addition to 141-FS Building	$ 77 999

Project unitization is progressing on the following projects which are scheduled to be completed in February:

CAH-790	High Level Radioactive Material Receiving and Storage Addition, 327 Building	$344 948
CAH-860	PRTR Fuel Element Access, 327 Building	$ 80 533

To eliminate a duplication of effort by CAO and HLO in the keeping of records of zirconium scrap material and R&D stock, CAO will discontinue maintaining records for this type of material effective January 1, 1961.

Thirty-one items valued at $9,186 were received at the Laboratory Equipment Pool during the month of January. Twenty-eight items were loaned or transferred in lieu of placement of requisitions valued at $11,663. There are currently 563 items valued at $222,327 located in the equipment pool representing 4.2% of total HLO movable cataloged equipment items and 1.4% of HLO equipment investment.

Expenditures for Equipment Not Included in Construction Projects through January 1961 are presented together with FY 1961 commitments in order to reflect total encumbrances against our FY 1961 allocation.

Program	Expenditures	FY 1961 Commitments	Total	Allocation	% Encumbered
02	$ 602	$ 969	$1 571	$1 877	84
03	6	17	23	25	92
04	389	372	761	885	86
05	14	7	21	53	40
06	28	22	50	100	50
Totals	$1 039	$1 387	$2 426	$2 940	83

Percent of equipment expenditure to allocation for the 02, 04, and 06 Programs are compared with our historical three year average for the same period.

Program	FY 1961	Historical Average
02	32%	40%
04	44%	27%
06	28%	30%

COST ACCOUNTING

R. T. Brown, a BTC recruit, completed his rotation in Cost Accounting and transferred to another HAPO component. Concurrently, S. C. Thomson, also a BTC recruit, was transferred to HLO Cost Accounting in January.

The Operating Cost control budget was adjusted to reflect the transfer of the Waste Disposal function from Chemical Research and Development to Laboratory Auxiliaries. This involved approximately $45,000. The control budget was also adjusted to eliminate the budget for GETR Irradiations from Experimental Gas-Cooled Reactor operating costs. This item of cost will be accumulated in a special general ledger account maintained by Contract Accounting.

An instruction letter was sent to HLO management for preparation of the Budget for FY 1963 and Revision of Budget for FY 1962. Personnel requirements for the Budget for FY 1963 and Revision of Budget for FY 1962 have been received from the HLO Sections, approved by the Manager - Hanford Laboratories and transmitted to Contract Accounting on the date due. Following is a brief summary of the personnel requirements:

Actual personnel 12-31-60	1 386
Increase by 6-30-61	26
Increase by 6-30-62	11
Decrease by 6-30-63	(4)
Budget at 6-30-63	1 419

Other phases of the budget are progressing as scheduled. Hanford Laboratories' requirements for Automotive and Heavy Mobile, Photographic, Office, Radio and Audio-Visual equipment were prepared and transmitted for HAPO consolidation. Data Processing requirements for FY 1962 and FY 1963 were reviewed with HLO management in January and submitted to Accounting Operation.

Special requests received during the month are as follows:

.2P - Technical Assistance - Dugway Radiation Test Facility. The estimated cost is $3,000. Dr. I. T. Myers, Radiological Physics, is the coordinator on this request.

.2Q - Fabrication of two glass cylinders for General Engineering Laboratories. Estimated costs are $850. Work will be performed by the Glass Shop, Technical Shops.

.2R - Prepare Plutonium Foils for duPont Company, Savannah River Plant. Estimated costs are $3,000.

Organizational cost code, 7522 - Reactor Engineering Development - Special Studies, was established, effective January 15, 1961, to accumulate engineering costs associated with the Super Critical Reactor Studies.

The quarterly report listing Hanford Laboratories planned expenditures of $5,000 or more for each item of material and off-site contract procured for research and development programs during the balance of FY 1961 was prepared and transmitted to Contract Accounting. The totals reported by major AEC programs were as follows:

02 Program	$126 000
04 Program	444 000
05 Program	17 000
06 Program	26 000
Total	$613 000

Arrangements were made with the Laboratory Facilities Operation to issue a monthly report containing inventory figures in connection with the Strontium-90 Program. This information will be submitted to the Chemical Processing Department.

A first draft of a "Fuel Element Fabrication Economics Study" prepared by Reactor Engineering Development was received January 13 for review and discussion at a meeting on January 16. Considerable time subsequently has been devoted to appraisal of manpower requirements, reject rates and cost estimates included in the report to assist in preparation of the second draft.

In connection with the present study under way at HAPO to effect economies and efficiencies in operation, a description of services performed by Hanford Laboratories which are classified as "general overhead" functions was prepared along with historical cost data. This information along with other data will serve as the basis for further HAPO study and evaluation.

Schedules and data were prepared for use by HAPO management in discussions early in January with the AEC - Division of Reactor Development people on program levels for FY 1961 and FY 1962.

Operating cost information was compiled for inclusion in the annual information meeting for employees presented by the Manager - Hanford Laboratories.

Action as indicated occurred on the following project during the month:

New Funds Authorized HLO

CAH-914 Rattlesnake Springs Radioecology Facility $18,300

Hanford Laboratories received an additional $35,000 allocation for Miscellaneous Capital Work Orders under $20,000. This allocation brings our FY 1961 funds up to $150,000. At month end, $107,200 had been expended and $17,200 was committed, leaving an unencumbered balance of $25,600.

Payroll Statistics

Number of HLO Employees	Total	Exempt	Non-Exempt
Changes During Month			
Employees on Payroll at Beginning of Month	1 386	654	732
Additions and Transfers In	20	9	11
Removals and Transfers Out	24	9	15
Employees on Payroll at End of Month	1 382	654	728

Overtime Payments During Month	January	December
Exempt	$ 9 034	$10 990
Nonexempt	15 868	22 360
Total	$24 902	$33 350

Gross Payroll Paid During Month		
Exempt	$573 461	$ 577 439
Nonexempt	367 638	458 495
Total	$941 099	$1 035 934

Participation in Employee Benefit Plans at Month End	January		December	
	Number	Percent	Number	Percent
Pension Plan	1 225	99.4%	1 229	99.4%
Insurance Plan				
Personal Coverage	1 374	99.5	1 379	99.8
Dependent Coverage	988		991	
U.S. Savings Bonds				
Stock Bonus Plan	71	35.9	75	37.3
Savings and Security Plan	1 060	85.5	1 060	85.4
Accident Insurance	801	58.0	797	57.6

Insurance Claims	January Number	January Amount	December Number	December Amount
Employee Benefits				
Life Insurance	0	$.	0	$.
Weekly Sickness and Accident	18	1 140	17	1 250
Comprehensive Medical	87	2 300	131	9 444
Dependent Benefits				
Comprehensive Medical	151	13 205	144	16 319
Total	256	$16 645	292	$27 013

Good Neighbor Fund	January	December
Number Participating	940	946
Percent Participating	68.1	68.3

W. Sale/bk
February 15, 1961

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
M. C. Lambert	Method for Increasing Rate of Dissolution of Uranium Oxide by Chlorine Gas in Fused Salts (HW-68232)
J. Dunn	Bearing Adjustment - Canned Motor Pumps
J. C. Spanner	A Method and the Apparatus for Measuring the Annulus Spacing Between Two Concentric Tubes
H. L. Libby	A Multiple Parameter Eddy Current Non-destructive Testing Device
C. A. Ratcliffe	An "Exclusive-Or" Circuit
D. F. Carroll	A Method of Plutonium Disilicide Preparation dated 1-17-61
J. W. Weber	An Oriented Capsule for Horizontal Irradiation of Fuel Samples
L. E. Mills	Superior Nuclear Fuel Element Cladding