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PACIFIC NORTHWEST LABORATORY
MONTHLY ACTIVITIES REPORT
FEBRUARY 1970
DIVISION OF PRODUCTION
AND
HANFORD PLANT ASSISTANCE
PROGRAMS
March 1970

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AEC RESEARCH &
DEVELOPMENT REPORT

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Classified by G. E. King

C-65, Plutonium Production
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Classification Cancelled and Changed To MONTHLY ACTIVITIES REPORT

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FEBRUARY 1970

By Authority of CG PR-2

WA Snyder, 2-9-94. Division of Production

By J. E. Maly, 2-18-94. and

Verified By J. E. Sawyer, 2-23-94 Hanford Plant Assistance

Programs

by the

Staff of Battelle-Northwest

F. W. Albaugh, Director

March 1970

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PACIFIC NORTHWEST LABORATORY

MONTHLY ACTIVITIES REPORT

DIVISION OF PRODUCTION AND HANFORD PLANT ASSISTANCE PROGRAMS

W. D. Richmond

ASSISTANCE TO DOUGLAS UNITED NUCLEAR

Summary

Program I

Approximately 90% of the digital programs for conversion of the N-Reactor simulation to a Hybrid System have been debugged.

The Inconel-steel couples and the stressed stainless steel specimens for the study on corrosion of Inconel heat exchanger tubing have been processed.

Program III

A series of gas-water partitioning experiments showed that during quiescent conditions for 24 to 28 hours 76 to 88% of the krypton escapes pools of water in containers with surface-to-volume ratios of 2.3 to 2.8. When the surface to volume ratio was reduced to 0.6, only 42% was evolved in a similar period.

Analysis of wind velocity data from Wahluke Slope and other Hanford sites showed that the terrain strongly influences the air flow in the 100 N Area.

Process Technology

The final portion of a test to examine the effects of galvanic coupling of Zircaloy-2 to aluminum, anodized aluminum

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and stainless steel holders on the subsurface concentration of hydrogen in the test samples was discharged from K-West Reactor after 14 months exposure.

The films formed on the carbon steel surfaces in N-Reactor are essentially crystalline, and the size of the crystals depends at least in part on the length of time the surfaces have been exposed to high-temperature water.

Oxidation testing of a number of graphite samples coated by DUN was completed. Relative rates of oxidation of 1/4 to 1/12 that of non-coated graphite have been obtained.

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ASSISTANCE TO DOUGLAS UNITED NUCLEAR

Program I - Basic Production

N-Reactor Simulation

(J. D. Lodge, Process Simulation and Analysis Section)

Approximately 90% of the digital programs for conversion of the N-Reactor simulation to a Hybrid System have been debugged. All the secondary system subroutines have been working as individuals; however, the entire system tied into the controller-simulator and primary system (analog) has not been made to operate satisfactorily. The secondary system is divided into six subroutines which include the steam generator primary side, steam generator secondary side, dump condensers, surge tanks, condensate headers and steam distribution system. The reactor and pressurizer are included on the analog computer section of the Hybrid.

Corrosion of Inconel Heat Exchanger Tubing

(D. A. Jones, Corrosion Research and Engineering Section)

Final discharges from remaining autoclaves were made and all testing was completed. Inconel-steel couples and stressed stainless steel specimens were inspected for general corrosion and stress cracking. All specimens were completely processed; metallography and final reporting is underway.

Program III - Environmental and Regulatory Technology

Noble Gas-Water Partitioning Studies

(L. C. Schwendiman and J. Mishima, Air Pollution Chemistry Section)

Six experiments were completed to help determine the ease with which noble gases are released from water pools under a variety of conditions. Krypton traced with ^{85}Kr was injected into an absorption vessel filled with hot (194-203°F) water. After an equilibration period of about two hours, the krypton concentration in the water was

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measured. In one of the six runs, room temperature water was used. The loss on transfer, with relatively little turbulence, to vessels with surface to volume ratios of 2.3 to 2.8 was measured and found to range from 5 to 13%. During the 2 hour cooling period some 29 to 37% was evolved in two hours. In a subsequent standing period of 24 to 26 hours, 86 to 88% of the krypton was evolved. In the one room temperature run using the opened absorption vessel which had a surface to volume ratio of 0.6, 7% was lost in the first two hours and 42% was lost from the water during the next 23 hours.

The data continue to show that a slightly soluble gas is rather quickly released from the pool, particularly during transfers in which mixing is turbulent. Large scale experiments are needed.

An available glass column 21 feet tall was investigated for possible extension of this work to more realistic depths of liquid and in which steam and inert gas bubbles can be utilized.

Meteorological Studies

(M. A. Wolf, Atmospheric Analysis Section)

Wind velocity data from Wahluke Slope and other Hanford sites gathered over a two-year period were used in the analysis of airflows affecting effluent emission from the N-Reactor stack. This analysis, incorporated in a preliminary report to DUN, showed significantly less frequent northerly winds at 100 N than at the Hanford Meteorology Tower and an absence of strong southwest wind at the former site. In addition, large differences in surface wind velocities over short distances and in terrain channeling of airflow were observed. Extensive streamlining based on the surface wind velocity data indicate that effluent from N-Reactor would travel over the Wahluke Slope 43% of the time, provided that the streamlines are indicative of actual air trajectories. Limited use of constant density balloons showed air trajectories corresponding to the surface streamlines.

Process Technology

Low Temperature Hydridding of Zircaloy

(B. Griggs, Corrosion Research and Engineering Section)

The final portion of a test to examine the effects of galvanic coupling of Zircaloy-2 to aluminum, anodized aluminum and stainless steel holders on the subsurface concentration of hydrogen in the test samples was discharged from K-West Reactor after 14 months exposure. Initial examinations of samples and holders for weight gain, corrosion and radioactive contamination have been made. Crud deposition on samples was slightly affected by holder material and averaged 1 mg/cm^2 for the 14 months exposure. Radioactivity of the crud layer on the holders increased from the 8 month exposure, but the sample activity decreased. Corrosion of the anodized aluminum holders was largely confined to the erosion of the anodic layer and corrosion of scratches and other imperfections. Much of the anodic layer was still intact after cleaning. Weight losses of 350 mg/dm^2 for the anodized pieces compared with 1860 mg/dm^2 for the bare aluminum holders. Weight losses for the cleaned Zircaloy test pieces were generally less than 10 mg/dm^2 . Preparation and analysis of samples for base metal hydrogen are now in progress.

N-Reactor Decontamination

(J. A. Ayres, Corrosion Research and Engineering Section)

The films formed on the carbon steel surfaces in N-Reactor are essentially crystalline, and the size of the crystals depends at least in part on the length of time the surfaces have been exposed to high-temperature water.

If the crystals are large, as might be expected for films on surfaces that have not been cleaned for an extensive period of time, the films will be removed relatively slowly by a reagent. If the crystals are small, as would be the case for surfaces that are periodically decontaminated, the films will be removed relatively rapidly.

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Samples of N spacers were cleaned with varying degrees of difficulty. For example, a sample from one spacer was cleaned after exposure for 1 hr to give a DF > 100, while a sample from a different spacer exposed under exactly the same conditions was relatively untouched after 1 hr and cleaned up only imperfectly (DF of 60) after 5 hr.

Complexing agents at extremes of pH are very effective film removers but are also very corrosive. In the neutral pH region (6-8), the reagents corrode the metal surfaces at very low rates, but efficiency is also lower. A balance must be attained to achieve satisfactory efficiency and low corrosion.

Diethylenetriaminepentaacetic acid (DTPA), while not as satisfactory as triethylenetetraaminehexaacetic acid (TTHA), is available at a reasonable price and does form relatively strong complexes with iron, cobalt, nickel, manganese, and most of the fission products. A 5% solution of DTPA, citric acid, and hydrazine appears effective for cleaning even dirty systems and is being evaluated for use in N-Reactor. To facilitate application in the N-Reactor system, the temperature must be below 90°C, preferably below 85°C. Under these conditions most films are removed in 30-60 min, but thicker films require considerably longer times. Corrosion rates for carbon steel average about 0.04 mil/hr. Galvanic coupling does not increase the rate, and, even after 5 hr, attack at weld junctions is very low. The surface, after film removal, is very active and will rust rapidly if exposed to oxygen. In actual operation, the pH should be increased to 10 with ammonia or hydrazine, and the system should be flushed thoroughly with pH 10 water before exposing to the atmosphere. This is common industrial practice.

A loop test is planned next month to evaluate a DTPA solution and to compare the results with a previous loop test using EDTA.

Coating Studies on TSX Graphite
(R. C. Giberson, Graphite and Polymers Section)

The purpose of the coating study is to determine conditions for coating graphite that would be applicable to an operating reactor and would result in a reduced graphite oxidation rate. DUN coated a number of samples under various conditions and requested BNW to determine their oxidation rate. Some preliminary findings were presented in the two previous monthly reports.

Two samples were coated by DUN in the KW snout facility. Oxidation testing of the samples was reported last month but is given here for completeness. The coating conditions and oxidation test results are given in the first table of this item.

A number of samples were coated by DUN in a large furnace. The samples were oxidized by BNW. Oxidation conditions were 6,000 ppm of water vapor in helium flowing at 500 cm³/min. Sample temperature was 890-900°C. The oxidations were done on a recording balance so that the rate of weight change versus time could be obtained. All samples were oxidized for at least 150 hours and showed significant protection factors of from 4 to 12 after 150 hours of exposure. The protection factor is defined as:

$$\frac{\text{Rate of oxidation for uncoated graphite}}{\text{Rate of oxidation for coated graphite}}$$

A summary of the various coating conditions is given in the second table in this item.

The following general conclusions can be made from the oxidation tests.

1. The type of organic reagent used, tetraethylsilane (TES), tetramethylsilane (TMS), hexamethyldisilane (HMDS), or combinations, makes little difference in the relative protection factors obtained.

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COATING AND OXIDATION RESULTS OF SAMPLES
COATED IN THE KW SNOUT FACILITY

Oxidation Conditions: 900 C, 25 mm of water vapor

Sample No.	Coating Agent*	$\Delta W, g$ from Coating	Flow Rate, cfm	Partial Pressure, mm	Time of Exposure, hrs	Sample Temp, °C	Rate, g/(hr)(g)		
							0-66 hrs	0-111 hrs	111-175 hrs
1T	TES	- .0073	35	6	66	560	4.22×10^{-5}	8.44×10^{-5}	5.15×10^{-5}
2T	HMDS	+ .0003	300	6	20	480	6.00×10^{-5}	5.54×10^{-5}	7.98×10^{-5}
A	None	-	-	-	-	-	5.28×10^{-4}	5.42×10^{-4}	4.55×10^{-4}

* TES = Tetraethylsilane, HMDS = Hexamethyldisilane

DUN COATING CONDITIONS - THERMAL ONLY

Test No.	Coating Agent	Partial Pressure, mm	Helium Flow Rate, cfm	Time of Exposure, hrs	Sample No.	Graphite Temperature, °C	Change in Weight, Grams
11	TES	6	100	5.8	1	650	+ .0046
					4	650	+ .0038
					6	650	+ .0025
12	HMDS	~ 6	100	5	1	550	+ .0025
					4	550	+ .0044
					2	625	+ .0042
13	TMS	~265	150	5	5	625	+ .0096
					1	500	+ .0035
14	TMS+	~265	150 (= 300 total)	4	5	650	+ .0397
	HMDS	~ 6	150 (= 300 total)		2*	500	+ .0005
15	TMS	~265	150 (= 300 total)	3	4	500	+ .0047
	TES	~ 6	150 (= 300 total)		8	600	+ .0279

a. TES = Tetraethylsilane, HMDS = Hexamethyldisilane, TMS = tetramethylsilane
* Not oxidized yet.

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2. Use of tetramethylsilane does give a weight gain reaction during initial water vapor exposure. Apparently either TES or HMDS does not give this reaction which suggests that the actual nature of the deposited coating is different for the different materials.

3. Test No. 14 which used the TMS/HMDS mixture showed a significant difference in the magnitude of the oxidation rate of the two samples. The oxidation rate ratio Sample 1 to Sample 5 was about 1.8 and constant with time. The difference in the coating temperature and weight gains from coating are believed responsible. A similar observation is made from Test No. 15 where the rate ratio Sample 4 to Sample 8 was about 1.6. Another possible explanation is that TMS gives better protection than the other organics. In each experiment one expects more TMS deposition at the higher temperatures. More data are needed on coatings using TES or HMDS alone to substantiate this conclusion.

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ASSISTANCE TO ATLANTIC RICHFIELD HANFORD COMPANY

Summary

Program I

Laboratory tests of the slag and crucible nitric acid concentration measurement assembly, which incorporates sensors for determination of conductivity and specific gravity, showed excellent results over the acidity range from 0.1M to 6.0M.

Studies related to monitoring Np and Pu in Purex HAW were directed toward modification of procedures for extracting Np from very dilute (10^{-7} M) solutions.

In Zirflex tonic studies substantial increases in zirconium DF have been obtained when a small amount of fluoride was present in the scrub solution and a small amount of plutonium was present in the organic phase.

Program II

Installation of the dissolver, off-gas equipment, and tanks in a shielded facility has been started. The equipment is part of that necessary for the processing of irradiated neptunium targets.

Program III

Work progressed in the solution of the problem of convergence in using the PST model for simulating waste leaks from pipes buried in the ground.

Detectors for measuring soil moisture content and soil moisture movement were planned for installation in a replacement well to be drilled about 3 miles south of 200 East Area.

A two-level factorial design experiment was conducted to measure the effect of concentration of H, Ca, Na and K ions on trace Cs sorption on a Burbank sand.

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The design of the 242-B facility for large scale aerosol release tests neared completion. Rocky Flats deposition specimens were unpacked, and the glove box was readied for examination of the samples.

Program IV

Twelve cerium activated vycor sensors, optimized for maximum alpha response and minimum beta-gamma response, are required for backup sensors for the Purex plant in-line contact alpha monitors. Four optimized sensors have been produced, three during the current month. Six sensor blanks have been returned to the manufacturer as unacceptable for processing.

Concentrations of NO_2 at three surface locations near an elevated source were generally low with relatively high concentrations confined to narrow sectors.

Mild steel weldments exposed to boiling 3M NaNO_3 -2M NaNO_2 , 2M NaNO_3 -3M NaNO_2 and 1M NaNO_3 -4M NaNO_2 solutions were not cracked after 21 months exposure. Mild steel weldments exposed to boiling 4M NaNO_3 -1M NaNO_2 -0.22M Na_2SO_4 solution were not cracked after six months exposure. Weldments exposed to boiling 4M NaNO_3 -1M NaNO_2 solution cracked in less than six weeks.

Loading capacity of Cs on Zeolon is reduced only slightly by irradiation and by contact with hydroxyl ion.

Laboratory studies are underway to demonstrate the feasibility of purifying B-plant strontium product by ion exchange techniques.

Additional experiments on the effects of feed concentration on strontium purification by ion exchange were completed.

Thermal conductivity measurements of sludge from the 116 TX tank have not been reproducible.

The FORTRAN V computer program SLUCE was used to estimate temperatures for various air rates and cake thicknesses in underground waste storage tanks.

Strontium-Cesium Waste Packaging Program

- A. The three-month SrF_2 -316L stainless steel compatibility tests indicated no attack at 400°C but extensive attack at 800°C .
- B. In experiments to determine methods for decontaminating completed waste capsules, no satisfactory method has been found for removing SrF_2 from welded surfaces.
- C. Studies on casting CsCl into a series of primary containers for encapsulation have continued. Transfer of molten CsCl was accomplished with the melt at 700°C and the lines heated to 600°C . Tracer studies to determine the efficiency of absolute filters in removing vaporized CsCl from the melter gas stream have demonstrated DF's for Cs in excess of 2000.
- D. Equations were derived for the packed bed ion exchange separation of cesium, potassium, and sodium. Experiments with binary cation systems are needed to determine the constants to be used in the equations.
- E. Correlations to estimate maximum temperatures around decaying line sources were applied to wastes containing several fission products and buried in shallow tunnel systems.
- F. Testing equipment for determining the thermal and mechanical integrity of Sr and Cs waste packages has been fabricated.
- G. Fabrication of the impact consolidation loading mechanism for SrF_2 compaction is approximately 50% complete.
- H. Good corrosion resistance was demonstrated for Duriron and for Hastelloy D in molten cesium chloride at 675°C . Duriron was only slightly corroded by cesium chloride solution at pH 1.5 during evaporation and drying at 400°C . Strongly acid solutions (1M HCl) of cesium chloride were highly corrosive to both alloys during evaporation and drying.

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A sample of Purex plant uranium product solution was found to contain a material that poisoned the platinum catalyst used in the production of uranium(IV). The poison has not been identified.

Uranium(IV) losses to the aqueous product stream during centrifugal contactor tests of hydrazine-stabilized uranium(IV) reductant were reduced when equilibrium conditions were obtained.

Hydrazoic acid buildup in stored solutions of uranium(IV) nitrate appears to be a function of the preparation technique.

Preliminary evaluations were made on six candidate processes for the solidification of current acid wastes.

Bases for developing conceptual flowsheets for the solidification of bulk salt waste were developed.

Process Technology

Huey test results were evaluated as a function of the type of condenser used in the test apparatus and also as a function of boil-up rate. Accelerated corrosion rates were obtained when an Allihn (open) condenser was used and also when a high boil-up rate was employed.

Studies on the movement of particles in a Lucite mockup of the Purex annular dissolver have continued. Evaluation of jetting solution from the dissolver without removing a large quantity of particles has been completed.

The average thermal conductivities of two basalt samples from the ARHCO deepwell test cores were 0.72 Btu/(hr)(ft²)(°F/ft) for Sample 1005 and 0.62 Btu/(hr)(ft²)(°F/ft) for Sample 1084.

Testing of filter socks and nutating disc pumps for use in the Plutonium Reclamation Facility was completed with satisfactory results.

Flowmeter test equipment has been installed in the 324 Bldg. preparatory to the evaluation of a 0 to 50 gal/min thermal flow meter.

The application of laboratory developed circuitry to low resistance measurements such as applicable to corrosion measurement was continued. A resistance comparison circuit was studied for possible application to thermally compensated low corrosion rate systems.

The duPont 400 process photometer for monitoring 2AF samples for nitrogen dioxide has been tested in a laboratory simulated sampler system and has been delivered to ARHCO personnel for field installation.

A field test to determine if gamma energy spectrum analysis can be used to find the sludge level of tank 104A in B-plant has been scheduled for the mid-March batch processing operation.

Difficulty has been encountered with MoO_3 solids during dissolution of burned ZPPR oxide fuel.

A study to measure a series of soil-chemical parameters for a group of Hanford wells was continued.

Pump tests run in well 399-5-2 indicate very tight (low permeability) confined aquifers in this area. The piezo-meter sampling pump was laboratory tested, and a maximum pumping rate of 0.7 gpm was obtained.

The ^{208}Tl -deuterium field test source is being installed in the probe.

Hanford transmissibility and aquifer contour map data were digitized onto magnetic tape for use in the VTT flow model.

A routine schedule for gamma scintillation-logging of 200 West Area wells is now in effect.

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The hydroseismic system installed midway between 200-E and 200-W Areas is operating satisfactorily.

A linear least squares fit program, operational on the Varian Data 622/i computer at the Critical Mass Laboratory, was modified to fit pulsed neutron source data. The program, presently in use, permits rapid access to the reduced experimental data and associated error analysis.

The SUKENO code has been modified to incorporate the option for specular reflection at external boundaries of cuboidal arrays. This option should be useful in calculations on infinite or semi-infinite arrays of fissile material. In addition, 16-group albedo data for thick paraffin, concrete, water and polyethylene are available for use with SUKENO. The data can be used in place of the usual reflector specification to avoid the sometimes costly procedure of tracking neutrons in a thick reflector material. One test problem has been successfully run using the modified SUKENO code.

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ASSISTANCE TO ATLANTIC RICHFIELD HANFORD COMPANY

Program I - Basic Production

Slag and Crucible Dissolver Acidity Sensor

(D. P. Brown, R. C. Weddle and W. G. Spear, Instrument R&D Section)

Continued laboratory examinations focused on the combined use of the measurement of conductivity and of specific gravity for the determination of the nitric acid concentration of solutions used in the slag and crucible dissolver. This technique should achieve the desired concentration measurement accuracy of $\pm 0.5M$.

Laboratory calibration and testing on the combined sensor assembly allowed initial analysis of performance (sp.gr. of 1.0 - 1.36 and conductivity of 0.03 - 0.9 mhos/cm) over the expected acidity range of 0.1M to 6.0M. The system is ready for installation at a 300 Area location for tests under simulated process conditions.

Monitoring of Np and Pu in HAW

(M. C. Lambert, Analytical Chemistry and Instrumentation Section)

Extraction of Np with solvents dibutylbutyl phosphonate (DBBP), di-2-ethylhexyl phosphoric acid (D2EHPA) and malonic acid is being studied to develop a method for monitoring Pu and Np in the Purex HA column waste stream. Concentration of Np in the waste stream is very low ($< 10^{-6}M$) which requires that the Np be extracted for analysis. The aqueous to organic ratio must be high (>10) to extract enough Np for subsequent analysis in the solvent. Contact of 5 ml of 100% DBBP with 10 successive 20 ml volumes of low concentration Np(IV) solution was made in an attempt to increase the Np concentration in the solvent to a level that can be analyzed by X-ray fluorescence. Results have not been obtained.

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Silver transmission targets are being prepared and tested for use as an emission source. With the silver emission as a source, Pu, Am, Cm, and Bk will not interfere with the Np analysis by X-ray fluorescence.

Zirflex Tonic Effect

(J. L. Swanson, Applied Chemistry Section)

The scrub behavior of tracer Zr extracted from feeds containing uranium carbide reaction products was previously found to be improved by the presence of as little as 0.001M fluoride in the scrub solution. Experiments have now been performed with higher Zr concentrations and with Pu present to give conditions more representative of those in the HA column. Zirconium DF was increased tenfold by the presence of 3.3×10^{-4} M F in the scrub with 1.4×10^{-4} M Pu in the organic phase.

Program II - Product Flexibility

Processing Irradiated Neptunium Target

(E. J. Wheelwright, Applied Chemistry Section)

The component parts of the dissolver for irradiated Np targets were fabricated and delivered. Installation of the dissolver, off-gas equipment, and tanks in 325 A Bldg. C-Cell was started. Design of a 5-liter ion-exchange column for installation in 325 A Bldg. A-Cell was completed, and the column is being assembled. Previous work on processing of Np impregnated graphite targets was reviewed prior to outlining further studies.

Program III - Environmental and Regulatory Technology

Radionuclide Transport Model

(M. H. Karr, Earth Sciences Section)

The use of the Partially-Saturated Transient (PST) flow model for solving a simulated pipeline rupture and high-level waste tank leak ran into unexpected computational problems.

Calculations were started using small time steps which were initially successful. As divergence of the flow began to take place, time step increments became very critical for solution convergence. Attempts to use previous step history to choose the convergent delta time were unsuccessful. The problems were unexpected because the test case of a two-dimensional column did not encounter these problems. Present efforts are directed to overcoming the problems, and it is anticipated that a method can also be found to increase the time steps to reduce the long computing times associated with the present algorithm.

A literature review was conducted to consider the movement of liquid and gaseous phases in Hanford soils. Recommendations were made to correlate the interrelationships of the different driving forces using the theory of irreversible thermodynamics. This type of approach will determine under what environmental conditions each driving force is predominant or taking a significant role in the overall movement of soil solution.

Field Measurement Methods

(M. H. Karr, Earth Sciences Section)

Soil psychrometers and temperature probes were emplaced at 5 to 10 foot intervals in a 310-foot well in order to measure soil moisture content and direction of wave movement. Attempts to pull the well casing were unsuccessful; therefore, a replacement well is planned adjacent to well number 8, about 3 miles south of 200 East Area. Precautions will be taken during drilling to assure that the casing in the new well can be pulled (removed) successfully. In this case the in situ soil moisture and temperature detectors will be installed at relatively close intervals from ground surface to the water table (ca. 320 feet). Plans are also underway to make a similar installation in a 50-foot hole.

Soil-Waste Interrelationships

(R. C. Routson and R. J. Serne, Water and Waste Management Section)

A two-level factorial design experiment was conducted to

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measure the effect of pH, (Ca^{++}) , (Na^+) , and (K^+) on trace Cs-sorption on a Burbank sand; the parentheses denote solution-normalities (equiv/liter). The Kd_{Cs} (ml/g) was chosen as a suitable measure of the sorption.

In a preliminary experiment a determination of the suitability of using small column or (and) batch techniques for the Kd_{Cs} measurements was made. In the column technique the sorption of a radionuclide is accomplished by leaching the sorbent column with solution until equilibrium is obtained, and the sorption is measured directly by counting equal volumes of influent solution and column sorbent. In the special case of ^{137}Cs sorption, passing an excess of 350 column volumes of influent solution through the soil was inadequate for the attainment of equilibrium. This is probably due to the slow "weathering" of interlayer K^+ from the mineral lattice of mica-like mineral which results in the production of new sorption sites for ^{137}Cs . Thus, this method of assessing the sorption of ^{137}Cs was found inadequate and was abandoned.

In the batch technique the effects of previously washing the soil with solution and of the solution-to-soil ratio on the ^{137}Cs sorption were examined. Two washes were found to essentially equilibrate the soil and solution phases. A solution-to-soil ratio of 50:25, or less, was found to result in essentially constant sorption when the soil was given two prewashes. Thus, this technique was chosen as suitable for the measurement of ^{137}Cs sorption.

The levels of pH, (Ca^{++}) , (K^+) , and (Na^+) used in the experiment were 5.0 - 8.2, 0.001 - 0.005N, 0.005 - 0.25N, and 0.05 - 0.5N, respectively. The determined regression equation describing the effect of above the above-ion levels on sorption was

$$Kd_{Cs} = -22.6X_K - 4.81 X_{Na} + 3.96 X_{Na} X_K + 35.3 \quad (1)$$

The equation is valid only for $-1 < X < 1$. The equation reflects the strong dependence of Kd_{Cs} on (Na^+) and ionic strength and the independence of Kd_{Cs} from pH and (Ca^{++}) .

Atmospheric Release of Radioactive Particles

(L. C. Schwendiman and J. Mishima, Air Pollution Chemistry Section)

Design of the large scale aerosol release facility neared completion. Liaison with Facilities Engineering continued, and supplemental funding was made available to complete the design.

Problems relating to examination of the Rocky Flats deposition samples received attention, and the glove box readied for the work. Methods for obtaining informative data from these samples with a reasonable expenditure were sought. Because of large differences in the physical form of the samples, widely different methods will be required for estimating the deposition and the nature of the material deposited. Samples were removed from the drum in which they were received.

Program IV - Waste Management

Alpha Scintillating Glass

(O. H. Koski, Analytical Chemistry & Instrumentation Section)

Twelve optimized vycor sensors are to be provided for plant inventory by the completion of the alpha scintillation glass development program. Three sensors were finished during this month and are equal or superior to the adopted standard optimized sensor. A group of ten crude sensors from the manufacturer were tested with only four found suitable for further processing. The remaining crude sensors were returned to the manufacturer.

A study was made to determine the effect of gamma radiation on an optical epoxy adhesive proposed for bonding the sensor to the photo multiplier tube. While the epoxy did not optically degenerate with radiation exposure, low level noise was generated by exposure of vycor to cobalt gamma. Tests have shown that low level light pulses are given off from the gamma irradiated vycor glass which cease if the sensor is heat treated. Also, a phosphorescence property of the irradiated vycor glass was

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observed. The effect of these properties on the plant use of the sensors has not been fully evaluated but is expected to be of minor significance.

A survey of several plant alpha measuring system pre-amplifiers revealed a system gain variation of over thirty in the units tested. Methods by which system gain can be measured and controlled are presently under study.

Gaseous Waste Assistance

(M. A. Wolf, Atmospheric Analysis Section)

The frequency of various levels of NO₂ concentration at three surface locations near the 200-E Area elevated source was correlated with wind directions measured on a nearby 12 ft mast and on the 200 ft level of the Hanford Meteorology Tower approximately four miles to the west. Low concentrations were found at all three sites regardless of wind direction. Relatively high concentrations were confined to a narrow sector at each site.

Corrosion Studies

(R. F. Maness, Corrosion Research and Engineering Section)

Mild steel weldments (1 in. x 3 in. x 1/2 in.) fabricated from ASTM A283, grade C and from ASTM A515, grade 60 were inspected after 21 months exposure to boiling 3M NaNO₃-2M NaNO₂, 2M NaNO₃-2M NaNO₂ and 1M NaNO₃-4M NaNO₂ solution. None of the weldments were cracked. Similar weldments exposed to boiling 4M NaNO₃-1M NaNO₂-0.22M Na₂SO₄ solution were inspected after six months exposure. None of these weldments were cracked. Weldments exposed to boiling 4M NaNO₃-1M NaNO₂ solution cracked in about six weeks.

Ion Exchange Removal of Cesium from Redox Alkaline Supernatant

(J. R. Lundquist, Applied Chemistry Section)

Laboratory studies on loading of cesium on Zeolon (a synthetic inorganic exchanger) were continued during the month. A total of 113,000 Ci of cesium can be loaded onto

3000 gallons of Zeolon. Calculations show that this amount of Zeolon, contained in a cylinder where the diameter of the base equals the height, would absorb 0.94 Rad/(sec)(cm³) from the 0.51 MeV cesium beta component and 0.09 Rad/(sec)(cm³) from the 0.662 MeV cesium gamma component for a total energy absorption of 1.03 Rad/(sec)(cm³).

To estimate the amount of radiation damage to the Zeolon that might be expected from this type of loading, a 40 cm³ sample of unloaded Zeolon was irradiated for 88.5 hours in a ⁶⁰Co source at a flux of 0.8×10^6 Rad/(hr)(cm³) which was equivalent to the exposure from ¹³⁷Cs loaded on Zeolon for 27 months. Subsequent Cs loading experiments showed the capacity of the irradiated Zeolon was only slightly reduced. In addition to the radiation stability tests, the same Zeolon sample was exposed to 2.7M hydroxyl ion for an equivalent of 3 months of plant operation. Only a small reduction in loading capacity occurred. From the standpoints of stability to radiation and hydroxyl ion exposure, Zeolon appears to be a good choice for extended plant use.

Purification of Strontium Product

(L. A. Bray, Applied Chemistry Section)

Laboratory studies are in progress to demonstrate the feasibility of purifying the strontium product from the B-Plant solvent extraction process by ion exchange techniques. Initial studies were completed by L. L. Ames and John Adams of the BNW Environmental and Life Sciences Division. Additional tracer studies are now in progress in our laboratory, and studies with samples from B-plant will be done in the 325-A shielded cells.

The flowsheet consists of adjusting the solvent extraction product with complexants (NTA and sodium gluconate), adjusting the pH to 8 with NaOH, and passing the feed through an inorganic exchanger (Linde Molecular Sieve - 13X). To date, the strontium, calcium, and manganese concentrations have been traced in three loading and elution cycles. A 5% breakthrough of Sr, Ca, and Mn occurred at 320, 19, and 2.6

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column volumes, respectively. Irradiation studies with ^{60}Co are in progress to determine the stability of the complexed feed and the 3M ammonium acetate elutriant. Initial results indicate that the strontium will precipitate as SrCO_3 from CO_2 which is produced by radiolytic destruction of the organics in both the feed and product solutions.

Purification of Strontium by Ion Exchange

(J. G. Adams and L. L. Ames, Water and Waste Management Section)

Additional experiments on the effects of increased concentration in the feed solution were completed and samples were submitted for analysis. Concentrations of 10X and 50X were studied at both 5 and 1 column volumes per hour. Since the constituents in the 50X feed would not remain in solution, valid data could not be obtained.

Waste Characterization

(D. G. Bouse, Applied Chemistry Section)

Close inspection of the Tank 116 TS sludge material used for determination of thermal conductivity revealed that it had dried in three distinct salt layers. The material was reground, wetted to form a thick paste in order to obtain homogeneity, then re-dried at 95°C for 112 hours. Attempts to duplicate the previous measurement on the reground material were unsuccessful. Measurements made at 50°C with different probes and power inputs show the thermal conductivity to be $0.294 \text{ Btu/ (hr) (ft}^2\text{) (}^\circ\text{F/ft)}$ as compared to $0.468 \text{ Btu/ (hr) (ft}^2\text{) (}^\circ\text{F/ft)}$ obtained previously at 25°C .

The probes that were purchased for measurements at temperatures up to 150°C were found to be unreliable, as indicated by resistance changes, when heated, that do not relate to temperature.

Underground Heat Transfer in Waste Tanks

(G. Jansen, Chemical Engineering Section)

Calculations of maximum temperatures were made for a wide variety of heat transfer conditions in underground tanks

containing solidified wastes. The calculations were made with FORTRAN V computer program SLUCE. The alternatives of water present--water not present and uniform heat generation--heat generation concentrated in layers were combined with variations in air rate from 0 to 5000 SCFM, average cake thickness from 0 to 6 ft, local cake thickness from 0.5 to 6 ft, and heat generation rates of 28 and 56 Btu/(hr)(ft³). Estimated maximum temperatures ranged from acceptable values well below the boiling point of water with water present and high air rates to unacceptably high temperatures with thick cakes, no water present, and no air cooling. It is clear that each specific set of experimental conditions must be evaluated individually because system thermal properties and operating conditions have such a strong effect on the maximum temperatures achieved.

Cesium-Strontium Packaging Program

The following lettered items describe progress on the various segments of work in support of the cesium-strontium waste packaging program.

A. Compatibility Studies

(H. T. Fullam, Applied Chemistry Section)

The six-month compatibility tests with radioactive CsCl and SrF₂ have been completed. The couples are now at radio-metallography for sectioning and photography.

The three-month SrF₂-316L stainless steel couples have been evaluated. No attack was evident in any of the couples tested at 400°C. All of the couples tested at 800°C showed extensive attack (up to 5 mils). The results raise some doubt as to the ultimate use of 316L to contain SrF₂.

The second set of test couples involving CsCl with welded 316L and with Hastelloy C are now at metallography. The couples were tested four months at 400°C. Preliminary microscopic examination of the couples indicates very little attack of the metal specimens.

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B. Decontamination Studies

(H. T. Fullam, Applied Chemistry Section)

Work continued on developing methods for removing CsCl and SrF₂ from metal surfaces. Electrochemical or ultrasonic cleaning using a variety of cleaning solutions can be used to remove CsCl from welded and unwelded metal surfaces and SrF₂ from unwelded surfaces. During welding the SrF₂ melts in the area around the weld and forms a surface glaze that is difficult to remove. None of the cleaning agents tried to date were successful in reducing the SrF₂ contamination on welded surfaces to an acceptable level. Some form of mechanical treatment, such as buffing or grinding, will be needed to effectively remove the SrF₂ glaze.

C. CsCl Melt Cast Studies

(L. K. Mudge, Chemical Engineering Section)

A process for casting molten CsCl into a series of containers is being developed to package radioactive CsCl. Molten CsCl at 700°C was transferred into a series of containers with the transfer lines, transfer head, and upper portion of the capsules heated to 600°C. Contamination of the weld area by CsCl was considerably less than when the transfer lines were heated to 700°C. Contamination of the weld zone is caused by CsCl splashing on the walls of the capsule near the splash guard followed by capillary flow between the wall and the splash guard to the weld area.

A tracer study using ¹³⁴Cs is being conducted to determine the efficiency of an absolute filter for removal of vaporized CsCl from a gas stream. Decontamination factors of 2000, >4000, and >5000 were obtained with a 2 l/min flow rate through a 50 cfm capacity absolute filter. Literature references indicate a strong dependence of filter efficiency on the face velocity, which varies depending on the condition of the filter. An absolute filter with a rated capacity of <3 cfm will be tested to simulate the projected face velocity through the filters that will be used in the plant process.

D. Cesium Purification by Ion Exchange
(G. Jansen, Chemical Engineering Section)

The purification of cesium by cation exchange involves the absorption of cesium, potassium and sodium on the inorganic exchanger, Zeolon H, followed by washing with a dilute NH_4NO_3 - NH_4OH solution. The loadings and column lengths are such that constant pattern breakthrough cannot be assumed and the presence of up to 4 cations prevents the direct use of analytic equations developed for binary systems. A set of first order differential equations has been derived. Numerical solution of these equations would be required to estimate column behavior. The equations require 6 equilibrium constants and 6 kinetic factors. Approximate values of the equilibrium constants have been estimated, but several binary cation column breakthrough curves would be needed to evaluate the kinetic factor. The solution of the system of equations would result in an approximate prediction of the influence of loading, scrub volume, and flow rate on the separation of potassium and sodium from cesium. An exact solution to the problem cannot be obtained because both the equilibrium and kinetic factors vary with cesium loadings.

E. Underground Cavern Waste Storage
(G. Jansen and L. G. Niccoli, Chemical Engineering Section)

Dimensionless correlations for heat transfer involved in direct burial of radioactive wastes in tunnels were developed. A dimensionless temperature parameter was correlated graphically and in tabular form as a function of a dimensionless time parameter and a dimensionless radioactive decay parameter.

By using the principles of superposition, the correlations can be a powerful tool for a wide variety of cases. These include (1) single line sources containing several heat generating isotopes, (2) two and three dimensional arrays of parallel line sources, and (3) line sources buried at a shallow depth in the ground so that heat transfer to the surface is important. A computer program is being developed to realize full advantage of the application of the correlations to complex cases requiring superpositions of many sources. Modifications of this

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program will also allow the inclusion of finite length sources and burials at differing time intervals.

As an example, the case of a single heat generator with a 30 year half life and an initial heat generation rate of 200 Btu/(hr)(ft of length) was considered. The surroundings had a thermal conductivity of 0.5 Btu/(hr)(ft²)(°F/ft) and a thermal diffusivity of 0.02 ft²/hr. The temperature rise 5 ft from the center of the line source (this might approximate a 10 ft diameter tunnel) passed through a maximum of 132°F at about 9.3 years. Including an additional heat source in the tunnel of 400 Btu/(hr)(ft of length) with a half life of 285 days results in a maximum temperature rise of 185°F at 1 year after burial. If a second tunnel containing a single heat source identical to the first is located 20 ft away, the temperature 5 ft away on a line between their centers reaches a maximum of 211°F above ambient at 13 years after burial. Burying the single line source 10 ft below grade results in a maximum temperature rise of 88°F above ambient 3 years after burial at a distance 5 ft below the source.

F. Capsule Integrity Testing

(J. Dunn, Chemical Engineering Section)

Double-walled metal capsules will contain radioactive strontium fluoride or cesium chloride. To insure package integrity and permit safe handling, a series of stringent thermal and mechanical tests have been proposed for the capsules.

All of the equipment for testing the capsules has been fabricated. The stainless steel tubing for 75% of the capsule fabrication has been received and sent to ARHCO for fabrication of the specified test capsules. The balance of the tubing has been back-ordered by the supplier and will be fabricated as soon as possible. Actual testing of the capsules will be started as the capsules become available.

G. Strontium Fluoride Densification
(K. R. Sump, Materials Development Section)

The machining and sheetmetal work on the prototype loading mechanism is over 50% complete. No millwright work has been done, and most of this work must be done after the prototype is finished.

The two main design changes to date are a ratcheting device rather than gears for rotating the tray and moving the hopper lid hinge to the front side. The change in hinge location was required for clearance with the air hammer. A short stroke air cylinder was obtained for raising and lowering the loading mechanism.

Ten alumina trays, 7 1/2 in. long, 5 1/2 in. wide, and 2 3/8 in. high, were purchased. The cost of these trays is \$37.80 each with discounts of up to 15% for lots of 100 or more. A couple of the above trays will be used in the prototype, and the remainder will be used for thermal shock studies at various temperatures.

A sufficient supply of previously processed SrF_2 exists for loading 3 simulated waste containers when they are available.

H. Corrosion Studies
(R. F. Maness, Corrosion Research and Engineering Section)

Corrosion rates for Duriron and Hastelloy D in molten cesium chloride at 675°C were 0.7 and 3.3 mils/mo, respectively, with no preferential attack. Specimens of Duriron and of Hastelloy D were exposed to 9M CsCl-1M HCl while the solution was evaporated to dryness and then dried at 400°C. Corrosion rates were 125 and 78 mils/mo, respectively. A similar test was made using a 9M CsCl solution adjusted to pH 1.5 with HCl. A Duriron specimen corroded at 2.5 mils/mo. Duriron appears to have more than adequate corrosion resistance to serve as a combined evaporation, drying and melting pot for the preparation of cesium chloride.

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Stressed 304L specimens were exposed to molten cesium chloride at 675°C (air atmosphere, 24 hr exposure) and to 9M CsCl-1M HCl solution (seven-hour exposure) during evaporation to dryness followed by drying at 400°C. Corrosion rates were about 80 and 275 mils/mo, respectively. In both cases the residual strength of the specimens was slight, indicating essentially complete intergranular penetration.

Platinum Catalyzed Hydrazine Reductions

(J. L. Swanson, Applied Chemistry Section)

A sample of uranium product solution from the Purex plant was found to contain a material that poisoned the Pt catalyst for U(IV) production when the solution (after addition of HNO_3 and N_2H_4) was passed through a bed of the catalyst pellets. The catalytic activity was regenerated by washing with HNO_3 . The poison has not yet been identified; the facts that it was not removed by passage through a bed of carbon and that it was not observed with a tributyl phosphate-saturated solution prepared from UNH crystals indicate that it is not organic.

Catalyst poisoning was also observed with nitric acid-hydrazine solutions in the absence of uranium. The poisoning occurred much less rapidly than with the plant product solution and was also reversed by washing with HNO_3 .

Alternative Purex Reductant - U(IV)

(D. G. Bouse, Applied Chemistry Section)

Centrifugal contactor runs were continued to test flow-sheets proposed to demonstrate the use of hydrazine-stabilized uranium(IV) nitrate as a reductant for plutonium in the Purex 1BX (first cycle partition) column. Early runs without Pu indicated 9 to 10% of the U(IV) left with the aqueous product stream if the 1BXU was introduced at the second stage from the bottom of the column. Losses of this magnitude were also noted in runs, with Pu present, during the first 3 to 4 hours operation with the 1BXU introduced 3 stages from the bottom; however, the loss dropped to 0% after 5 hours operation. In a recent run (Pu present) with the 1BXU introduced at the second

stage from the bottom of the column the U(IV) loss was fairly steady at about 9.5% after 6 hours operation. About 99.5% of the plutonium was stripped during this run.

Since the U(IV) material balance across the column has continually changed during runs of 5 to 6 hours duration, a 9-hour run was made in an attempt to reach equilibrium conditions. Even with the 1BXU introduced 3 stages from the bottom of the column, U(IV) was still detectable in the aqueous product at the end of the run (14%). The U(IV) in the organic was fairly constant during the last 6 hours at about 6.2%. Plutonium stripping was also constant at 99.5%.

A third run was made in which the organic residence time was reduced from 2.5 minutes, as used in previous runs, to 1.25 minutes. With the higher flow rates used for this run, equilibrium conditions were reached more rapidly. After 6.5 hours operation, no U(IV) was detectable in the aqueous product and the organic U(IV) concentration was constant at about 11%. About 99.5% of the plutonium was stripped, but about 60% of the neptunium was also stripped.

Hydrazine Reaction Products

(J. L. Swanson, Applied Chemistry Section)

Hydrazoic acid can be formed in the Purex 1BX (first cycle partition) column when hydrazine is used as a nitrite suppressor. A search is underway for a method of destroying the hydrazoic acid. Initial efforts have met with only partial success; contacting TBP-NPH solutions of hydrazoic acid with solutions of peroxide or sulfite gave only partial removal of the hydrazoic acid.

The rate of hydrazoic acid formation and its equilibrium concentration in aging uranium(IV) stock solutions is also being studied. With 0.5 to 0.7M U(IV) solutions prepared by reduction with Al metal in the presence of hydrazine, hydrazoic acid concentrations of 0.02 to 0.03M were found in the freshly prepared solutions. Storage of the solutions under a variety of conditions led to an increase in the hydrazoic

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acid concentration only when the container was tightly sealed. The highest concentration found has been 0.13M. No hydrazoic acid has been found in fresh uranium(IV) solutions prepared by the platinum catalyzed hydrazine reaction. Formation of hydrazoic acid has occurred during storage of such solutions, even in vented containers. The highest level found to date is only 0.015M, however.

Preparation of Uranium (IV)

(G. L. Richardson, Chemical Engineering Section)

A laboratory-scale slurry uranium reductor has been fabricated to test the feasibility of continuous reduction of U(VI) to U(IV) by platinum-catalyzed hydrogen (or hydrazine). The reductor concept is similar to the batch slurry reductor developed at Oak Ridge National Laboratory to prepare uranous nitrate as the first step in preparing urania sols.

Solidification of Current Acid Wastes

(J. L. McElroy, Engineering Demonstration Section)

Preliminary evaluations were made for the six candidate processes (and two other adaptations of two of the processes) for solidifying the three Purex high heat wastes. The processes selected are: pot calcination, spray calcination (including in-pot melting), phosphate glass, fluidized bed solidification, the French pot vitrification and the British FINGAL glass (including rising level glass) processes. For the preliminary evaluation, the major emphasis was to determine the applicability of each of the processes for solidifying the Purex wastes and to tabulate data on each process to facilitate an easy comparison for selection of the most promising for further study.

The number of solidifiers which would be required for each waste has been determined (where no scale-up data are available, the number is the number for which present technology exists) and the number of cylindrical storage pots required was calculated. From this the effect of cleaning up the waste before solidification becomes obvious. For the

partial cleanup waste (sulfate removed) the volume of solidified product is reduced by a factor of two and for totally clean waste (sulfate removed and mechanical decladding) the volume is reduced by a factor of about six. Although the number of storage pots does not necessarily decrease as the waste is cleaned, the decrease in pot size is significant.

Solidification of Bulk Salt Waste

(W. K. Winegardner, Engineering Demonstration Section)

Review of potentially applicable processes for the solidification of Hanford bulk salt (low heat) wastes revealed several existing processes that can be used as bases for developing conceptual flowsheets. Despite the available technology, research and development is needed in every instance to improve safety aspects of the solidified waste--specifically to decrease the possibility of dispersion by water.

Two types of solidification techniques with sufficient technology to permit immediate consideration are:

- high temperature calcination processes; and
- low temperature processes, ranging from conventional evaporation to processes that attempt to immobilize radioactivity of the waste into a second media, e.g., asphalt, plastic, or cement.

Natural water movement is presumed to be the most likely driving force for dispersion. The salt cake arising from evaporation is soluble in water and the leach rate of solids from calcines and cements are high. As in the case of low temperature processes, chances for dispersion can be significantly reduced by incorporation of the solids from calcination into a second material (initial studies suggest the use of glass formers). Asphalt is currently being used to improve the solid from low temperature processes. However, recent studies resulted in the recommendation that asphalt not be used for the fixation of oxidants such as nitrates. Polyethylene may be suitable for use with oxidizing salts.

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The technology for storage, in a retrievable fashion, of solidified nuclear wastes was reviewed. The technology that has been developed for the storage of spent fuels or for the use of water filled pools also has immediate utility.

Process Technology

Corrosion Studies

(R. F. Maness, Corrosion Research and Engineering Section)

Specimens of several "lots" of 304L tubing recently purchased by ARHCO were evaluated for resistance to intergranular attack (Huey test). Five of nine lots tested failed the test. However, evaluation by an independent testing laboratory indicated all heats possessed excellent resistance to intergranular attack. Other cases in which rather different Huey test results were obtained at different laboratories have been noted. A study has been initiated to determine the reason for these discrepancies. The corrosiveness of the test solution is known to be markedly increased by the presence of corrosion products, especially Cr(VI). Thus the apparent variables to evaluate are those which affect the recycle of NO₂ which in turn determines the Cr(VI) content of the test solution. The type of condenser (cold-finger, Friedrichs or Allihn) and boil-up rate are currently being evaluated. A specimen from a "lot" of the previously mentioned 304L tubing which barely failed the Huey test when a test system employing a cold-finger condenser was used also just failed when a Friedrichs condenser was used. The corrosion rate exceeded specifications by a factor of about five when an Allihn condenser was used. Similar results were obtained with specimens fabricated from a different heat of 304L. A "Medium" boil-up rate was used in these tests. Evaluations were made with test systems employing cold-finger condensers in which the boil-up rate was the variable. Results obtained with a low boil-up rate did not differ significantly from those obtained with a medium boil-up rate. However, rates were increased twofold when a high boil-up rate was used. All tests were made with a solution volume to specimen surface area ratio of 125 ml/in².

Purex Dissolution of PRTR Type Fuels

(W. J. Nicholson, Chemical Engineering Section)

Particle concentration measurements at several locations in a Lucite mockup of the Purex annular dissolver were continued as support for the planned dissolution of Plutonium Recycle Test Reactor (PRTR) fuels. The evaluation of jetting a solution from the dissolver without removing a large quantity of particles has been completed.

Thermal Conductivity Measurements of Basalt

(G. Jansen, Chemical Engineering Section)

The thermal conductivities of two samples from the ARHCO deepwell test cores were determined. The average thermal conductivity of Sample 1005 was $0.72 \text{ Btu}/(\text{hr})(\text{ft}^2)(^\circ\text{F}/\text{ft})$. The average thermal conductivity of Sample 1084 was $0.62 \text{ Btu}/(\text{hr})(\text{ft}^2)(^\circ\text{F}/\text{ft})$. The average values are for the temperature range 100°F to 600°F .

Densities, heat capacities and thermal diffusivities of the samples were measured under the direction of J. H. Kleinpeter of the Graphite and Polymers Section of PNL. Thermal conductivities were calculated from the measured quantities. Heat capacities, determined by a differential scanning calorimeter, varied from 0.17 to $0.23 \text{ Btu}/(\text{lb})(^\circ\text{F})$. As the temperature increased from 100°F to 600°F , the thermal diffusivities, measured by a thermal pulse method, ranged from $0.021 \text{ ft}^2/\text{hr}$ at 100°F to $0.018 \text{ ft}^2/\text{hr}$ at 600°F . Room temperature densities, determined by a mercury porosimeter, were in the range 165 - $185 \text{ lb}/\text{ft}^3$. The average thermal conductivities were about 25 percent lower than those reported for basalts from MOHOLE samples taken near Hawaii and from the Nevada atomic test sites.

Plutonium Reclamation Facility Support

(J. Dunn, Chemical Engineering Section)

Removal and recovery of insoluble particles from the circulating dissolvers in the Plutonium Reclamation Facility (PRF) is desirable to promote operating efficiency and to

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decrease waste losses. A filter system designed by BNW was constructed and satisfactorily tested using a simulated dissolver effluent. Recovery of over 99% of the solids from a slurry volume representing 16 hr of plant production under worst case conditions was effected in the desired time at the desired throughput rate. The two filter cases were shipped to PRF for installation in the production plant.

Nutating disc pumps were tested for stabilizing flows in the organic feed stream. Satisfactory operation of two different sized, corrosion resistant Teflon pumps was completed, and the pumps were sent to the Plutonium Reclamation Facility for installation.

Organic Flow Meter

(O. H. Koski, Analytical Chemistry & Instrumentation Section)

A flow test system composed of a thermal flow meter, a rotometer and a turbine flow meter was installed in the 324 Bldg. The purpose of the system is to provide calibration and operational information on the one inch thermal flow meter which has a projected use of 50 gal/minute. Preliminary interest stems from the obstructionless and glandless design which is available in radiation resistant construction.

The preliminary tests on this system showed that the available pumps were insufficient to cover the desired flow span.

Corrosion Probe Development

(O. H. Koski, Analytical Chemistry & Instrumentation Section)

Circuitry originally developed for electrodeless conductivity is being modified and studied for application to corrosion measurement.

The stability of a system utilizing a single (resistance-corrosion) element in the fractional ohm range was improved by a factor of two through the substitution of a field effect transistor for a bipolar operational amplifier.

A resistance comparison configuration for use in thermally compensated and low corrosion rate systems was studied. Full scale output of this configuration is obtained by three percent changes in resistance when comparing resistances of 0.1 ohms. With a two percent accuracy full scale resistance changes of only 6 parts in ten thousand can be detected.

Purex Plant 2AF Nitrite Monitor

(R. D. Dierks, Analytical Chemistry & Instrumentation Section)

The duPont process photometer intended for the Purex plant 2AF sampler system was operated continuously for approximately seven weeks. During this time no significant deviation was noted in the zero or calibrated readings when the instrument was sampling ambient air.

The instrument system was studied to determine its range capabilities, the function of the various options and the interrelation of the span and zero adjustments, if any.

A simulated sampling system was set up in the laboratory that included the prototype phase separation and the process photometer. Air and liquid rates were varied to determine the capabilities of the phase separator, and HNO_3 and NaNO_2 concentrations were varied to determine the sensitivity of the photometer.

The instrument system studies were completed and the photometer and phase separator were delivered to the Purex plant for installation.

U-Pu Isotopic Analysis

(U. L. Upson, Analytical Chemistry & Instrumentation Section)

Estimates of the significant environmental factors at the proposed instrument location are being made on the basis of flow sheet data, subject to modification through discussions with customer operating personnel, both for "normal" fuels and for some anticipated "exotic" fuels.

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Sludge Level Detector

(A. L. Jackson, Analytical Chemistry & Instrumentation Section)

Radioactive waste containing primarily ^{137}Cs and ^{90}Sr is pumped into a settling tank in B-plant. The supernate liquid is pumped off, and the sludge is further processed for recovery of ^{90}Sr . A sludge level detector is desired to indicate the supernate removal cutoff point.

The ^{137}Cs is evenly distributed between the supernate and the sludge fractions while most of the ^{90}Sr is in the sludge fraction. It was proposed to determine the sludge level by scanning the tank for the appearance of bremsstrahlung from the 2.27 MeV beta emission from the ^{90}Sr daughter, ^{90}Y , in the gamma energy spectrum. A collimator was designed and fabricated and test scanning of the tank was scheduled for the mid-March batch processing operation.

Reprocessing ZPPR Scrap

(G. F. Schiefelbein, Applied Chemistry Section)

Tests of a previously developed dissolution flowsheet for burned ZPPR fuel (68% UO_2 - 28.6% PuO_2 - 3.4% MoO_3) were conducted using actual material from Rocky Flats. The oxide was dissolved in 15.5M HNO_3 - 0.65M HF to yield a final dissolver solution containing 70 g/l plutonium. A residue of MoO_3 solids amounting to 2.4 wt% of the total oxide charged accumulated during the dissolution tests.

The solids were separated from the dissolver solution by settling and decanting and were then dissolved in NaOH solution. The method of solid removal is not a convenient procedure for use in the Plutonium Reclamation Facility. The small particle size of the MoO_3 makes direct filtration difficult; vacuum filtration rates of only about 1.14 ml/min/in² were obtained.

Soil-Chemical Parameters

(R. C. Routson, Water and Waste Management Section)

A study to measure a series of soil chemical parameters for a group of Hanford wells was continued. The pH measure-

ments in a saturated paste and in 0.01M CaCl_2 for soil samples from well #1 were completed and reported.

Confined Aquifer (Surface)

(M. H. Karr, Earth Sciences Section)

A 24-hour, single-well pump test and two shorter tests run on well 399-5-2 provided excellent recovery curves. The well penetrates 230 feet of the basalt sequence, including three basalt flows and the two sedimentary beds that constitute the total Beverly Member. The coefficient of transmissibility is still less than 1 gallon per square foot per day for a unit gradient. The measured gradient of 15 ft in 20,000 ft suggests an almost non-existent flow rate.

Most deep basalt wells in the Columbia Basin have a specific capacity of one gallon per minute per foot of draw-down. The specific capacity of well 399-5-2 is less than one-half that. The well evidently lies in a low transmissibility zone that extends southeastward in the direction of flow indicated by the piezometric gradient. Thus wells north of Pasco have a specific capacity of about 1/2 gallon per minute per foot of drawdown. The decrease in permeability and transmissibility southeastward in the flow direction probably is the cause of the artesian head.

Construction of an isopach map of the aquifer shows that the waters in the aquifer near well 399-5-2 are moving normal to the course that the Columbia River followed when it deposited the aquifer sediments. Geologic data thus explain the south-eastward decrease in permeability, aquifer thickness and transmissibility.

A performance test run in the laboratory with the piezo-meter-sampling pump showed a maximum flow rate of 0.7 gpm. The pressure limitation of the solenoid valve was the constraint on achieving a greater pumping rate; therefore, a new valve with a higher pressure limit has been ordered. Fabrication of the final pump components was completed by the shop and the bridge rectifier circuit was wired and tested.

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Field testing is expected to be completed in early March.

Deuterium Field Test

(M. H. Karr, Earth Sciences Section)

The ^{208}Tl source for use in the deuterium-injection field test is being installed inside the probe (in a hot cell) which will then be placed inside a cask. Well pipe for the first field test was received.

Calculation of Transmissibility

(M. H. Karr, Earth Sciences Section)

The graphical digitizer was interfaced into the computer display system, and initial tests appeared successful. However, attempts to utilize it were unsuccessful because of equipment failures, and two visits from manufacturer's representatives did not correct the problem. Due to these delays, the transmissibility map and aquifer bottom contour map were digitized onto magnetic tape at the University of Washington Computer Center. Work is now underway converting these records for use in the model.

Field Measurements

(M. H. Karr, Earth Sciences Section)

Gamma scintillation logging of monitoring wells in 200 West Area is now underway after general overhaul of the Widco Logging System (the overhaul was necessitated by the great amount of use this system has received over the past ten years). The equipment was also used to obtain a continuous temperature log of well 32-49B after abnormal soil temperatures were reported during drilling operations. No significant variations in hole temperatures were evident from this survey.

A hydroseismic system designed to detect and continuously record earthquake occurrences was placed in operation at well 40-62, midway between 200-E and 200-W Areas. The system records short and long term exogenic fluctuations in the groundwater

levels on a micro scale. The system appears to have a response sensitivity of about 10 microns. No local earthquakes were detected during the past seven days of operation. A significant increase in microseisms, probably associated with two nearby storm systems, was recorded in February. The microseisms occurred on an average of once every ten minutes during the storm period within a bandpass of 1-5 hertz and showed a maximum displacement of 5 mm in the water level. Because the response to atmospheric changes tends to mask that from earthquake waves in well 40-62, the system will be moved periodically to other wells on the project as a means of improving performance.

Pulsed Neutron Source Data Analysis

(L. E. Hansen, Critical Mass Physics Section)

Pulsed neutron source experiments yield data on the prompt neutron decay constant which can be related to the reactivity of a multiplying system. A linear least squares fit program, operational on the Varian Data 622/i computer at the Critical Mass Laboratory, was modified to fit pulsed neutron source data. The program, presently in use, permits rapid access to the reduced experimental data and associated error analysis. This capability will result in savings in time and cost of pulsed neutron source experiments. Data can be analyzed while the experiment is in progress, and, if necessary, the experiment modified.

SUKENO Code

(L. E. Hansen, Critical Mass Physics Section)

A version of the KENO Monte Carlo code incorporating the option for specular reflection at external boundaries of cuboidal arrays was obtained from ORNL. In order to utilize the reduced running time of SUKENO, the PNL version of KENO, the necessary modifications for the option were made in the SUKENO code. This albedo input option permits specification for return of all or a given fraction of neutrons. The principal use of the option is in calculations on infinite or semi-infinite arrays of fissile material.

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Sixteen-group albedo data for paraffin (4 incident angles, 30 cm thick), concrete (4 incident angles, 60 cm thick), water (4 incident angles, 30 cm thick) and polyethylene (4 incident angles, 30 cm thick), computed at ORNL and supplied with the modified version of KENO, are available for use with SUKENO. If desired, the data can be used in place of the usual reflector specification to avoid the sometimes costly process of tracking neutrons in a thick reflector material.

One test problem has been successfully run using the modified SUKENO code, and further tests are in progress. This version of SUKENO also includes the capability, noted in the January report, for inputting modified Hansen-Roach cross sections from a library tape.

TECHNICAL ASSISTANCE TO THE HANFORD PLANT

Summary

Dosimetry Technology

Studies of low temperature annealings to determine a satisfactory procedure continued. The neutron shielding code ANISN was used with tissue equivalent proportional counter data to help interpret multi-purpose dosimeter exposures to neutrons. The Feasibility and Systems Study was approved and procurement of a computer was begun.

Columbia River Studies

Work was concentrated on total review of the COL-HEAT and MAXPWR programs and on addition of the computational refinements required by extensive use on related analysis programs. Additional field tests using remote optical scanning are being run in order to better understand effects of heat (density difference) on mixing characteristics.

Thermal Effects Study

Differential predation tests were conducted on juvenile rainbow trout at several durations of exposure to 27, 25 and 23°C. Predation differences were identified at each shock temperature.

Experimental techniques for the production of gas bubble disease symptoms were developed. The surgical techniques for implantation of the Doppler probe to determine the onset of bubble development are now ready. A surveillance of gas saturation in the river was planned.

Plans were made with the U. S. Bureau of Commercial Fisheries for limited sonic tracking studies in 1970.

Data analyses of food organisms from juvenile chinook salmon continued.

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C. columnaris isolates from coarse fish continued to be evident during the coolest winter river temperatures, a condition which has not been observed in previous years. The abundance of furunculosis-infected fish during the winter suggests that the pathogen is not as temperature-dependent as C. columnaris.

Mortalities in juvenile steelhead exposed since early July to approximate Columbia River temperatures and to added increments of 3, 4 and 5°F range from 4.0% in the 5°F increment to 15.3% in the 3°F increment.

Activity of insect larvae in the river proper and in the heated channels remained at a minimum. These are indications that midges are ovipositing in water heated 5°C above base river temperatures. Plans were formulated for expansion of studies in subsequent months.

Radiation Protection

Evaluation of the basic thermoluminescent dosimeter continues. Annual reports summarizing 1969 exposure information were issued. Autopsy samples were analyzed for americium on specially calibrated detectors.

Environmental Evaluations

While several radioactive waterfowl taken near 100-K could conceivably cause significant human exposure, the likelihood and consequences of this are believed to be small. A special shoreline survey between 100-B and 100-F revealed no conditions significantly different from those downstream from 100-F. Airborne radioactivity from fallout remained at the same level as the last reporting period and as a year ago. Special soil samples were obtained from the Hanford environs for plutonium analysis. Environmental radioactivity measurements indicated no unusual sources of exposure to the population or environs.

TECHNICAL ASSISTANCE TO THE HANFORD PLANT

Dosimetry Technology

(A. J. Haverfield, Radiological Physics Section)

Studies conducted during January and February to determine a quick anneal procedure for the Basic Dosimeter continued. Oven annealing temperatures at 80, 90 and 100°C were investigated with time periods from 20 to 40 hours. An annealing period of 24 hours was found to be satisfactory. Additional conditioning time did not seem to alter or improve results. Currently, a 90°C temperature is gaining attention because, at this annealing temperature, the 80°C peak is assured to be annealed out. Oven annealing temperatures at 100°C appear to be too severe. Discoloration of the identification label occurs, and care must be taken to prevent warping of the dosimeter.

The design of an improved heater unit for the Basic Card Reader progressed. The concept appears sound and no difficulties in fabrication are envisioned.

Several sets of tissue equivalent proportional counter (TEPC) measurements taken with monoenergetic neutrons were compared with the ANISN neutron shielding code to compare theory and experiment before interpreting the result of the multipurpose dosimeter exposure. The comparisons were accomplished with 0.73, 1.5 and 4.3 MeV fast neutrons using 2, 4 and 6 inches of polyethylene between the source and detector.

The measured and calculated results agreed quite well at 0.73 MeV. At 1.5 MeV, the differences are about 10%. At 4.3 MeV, the differences are 40 to 50%. For both the 1.5 MeV and 4.3 MeV cases, the calculated dose is higher than the measured dose. This is probably due to the cross sections used in ANISN and to the techniques in analyzing the TEPC data. Any dose due to gammas generated in the polyethylene is biased off when using the TEPC. For the thick shields, a certain amount of the total dose could be ignored.

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These measurements can help in understanding the response of the neutron section of the multipurpose dosimeter when moderators are present. The response of the dosimeter does not follow the same function of moderator thickness as the TEPC does, but the TEPC dose measurement and the calculations are used to interpret the dosimeter results.

A commercial thermoluminescence detector (TLD) is being modified for use in the Radiological Physics laboratory. The electronic controller circuit board is now installed and operating. Brief experience with the detector has found the dark current to be quite low (4.7 pico amperes) at the best operating voltage--a relatively high 1200 volts. At this voltage the light source current to dark current ratio is the highest. The planchet temperature controller was calibrated by using the melting point of tin and the boiling point of ethyl alcohol. The melting point of tin, 231.9°C, is right in the temperature region of most importance for reading LiF TLD material. The varacter bridge, electrometer, logarithm converter, storage XY oscilloscope and digital voltmeter were connected together for digital and analog readouts of TLD blocks. The differentiating log circuit to extract the logarithm of the photo current from the integrated photo current signal has so far proven unstable at the desired gain. The storage XY oscilloscope previously used was ruined by water that leaked from a valve in the attic above the lab.

An alternate bid for using Lexan in the multipurpose dosimeter was requested from commercial manufacturers. Since that request was made, samples of Lexan were obtained and non-destructively tested. Tests indicated that Lexan did not meet the mechanical properties of Noryl.

An engineering drawing was prepared for the multipurpose housing and a requisition for prototypes was prepared. Cycolac, the plastic used in our current dosimeter, was specified for the prototypes.

The Feasibility and Systems Study for the small computer was resubmitted and approved. The specifications were written and approved. Preliminary specifications for the computer program were rough drafted.

Columbia River Studies

(R. F. Foster, Environmental and Life Sciences Division)

Mechanisms of Environmental Exposure

(J. F. Honstead, Radiological Physics Section)

Plans are essentially firm for conducting a survey of a population living in a seafood production area on the Oregon coast. The site is in Tillamook County, Oregon, and consists of a cluster of small communities located on Tillamook Bay. The area is served by a rural school district which will be used as the local means of contacting people in the region of interest. The Oregon State Board of Health has joined in the promotion and conduct of the survey. The principal objective of the study is to obtain information concerning the amount of various types of seafood consumed by a representative group of local residents. In addition the participants will be measured in the mobile whole body counter to determine body burdens of various radionuclides. The ^{65}Zn burden will represent the only nuclide of Hanford origin reaching this population by way of seafood. Thus, the ^{65}Zn measurements may be correlated with seafood consumption data to identify the contribution of various kinds of seafood and to verify the validity of consumption estimates.

The local school administration and school board have agreed to cooperate in the conduct of the survey. In a faculty meeting the purposes and plans for the survey were related to the teachers involved, and a schedule was arranged. All of the nearly 400 students in high school will be reached in a series of talks on April 15-17. Whole body counts will begin on April 20 and continue until all volunteers have been measured, estimated to be about two weeks. The students will be provided with special questionnaires designed to obtain consumption level data. For this purpose the questionnaires will contain a series of photographs of various kinds of seafood from which the participant can designate serving sizes.

In addition to high school students the seafood survey will be extended to employees of seafood packing companies

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and their families. This group is selected to represent the critical population group for seafood consumption, probably including the maximum seafood consumers. The survey of this group will be conducted after school hours in the evening. Present plans call for an approach to these people through their employer, but on a voluntary basis. The owners and managers of the several small seafood packing firms on Tillamook Bay will be contacted and invited to meet on April 14 to learn about the survey.

In conjunction with population surveys to obtain consumption data and to make whole body counts, it would be useful to collect data on background dose levels in the environment. The anticipated environmental dose levels range from 10-15 $\mu\text{R/hr}$. Tests are being performed to determine the reliability of various available methods for measuring such dose levels. For this purpose ion-chamber pencils, calcium fluoride (Dy) thermoluminescence dosimeters, and a 2x2 inch sodium iodide (Tl) scintillation crystal are being examined. The instruments are being calibrated for integrated dose measurements using a very small NBS radium standard source. Probably all three techniques will be used during the survey on the Oregon coast.

Effects of Reactor Effluent on the Quality of Columbia River Water

(R. T. Jaske, Water Resources Systems Section)

Primary emphasis was placed on computer program development based on previous dye tests and the planning of additional tracer releases to confirm computed coefficients for COL-HEAT and related codes.

To improve the accuracy of the transport for highly transient systems, additional routines for correcting water volume and surface areas in response to flow changes are being refined. These routines permit different flows at each end of the channel array with resulting temporal and spacial variation in volume and area in each section. In some cases it is advantageous to permit the program to select "section" lengths on the basis of the hydraulics in the various

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reaches under examination and of known transport properties. A characteristic application of this capability is the computation of thermal or radionuclide levels in the river below reactors under any feasible operating circumstances which result from the combination of plant operation and dam transients.

Analysis of previous dye releases continued. Sufficient information exists from these tests to determine fully dispersion coefficients and related COLHEAT internal mixing coefficients in the reaches between Columbia River miles 370 to 380. Both the lateral and longitudinal dispersion coefficients are being evaluated. Additional field tests to determine the effects of effluent density variances on the mixing of warm and cold effluent on the numerical values of these coefficients are being run using a combination of dye releases and remote sensing apparatus. The latter uses optical mechanical scanning recorded on magnetic tape. This real time data collection permits close examination of the mixing process and a better approach to the development of theory concerning the physical mechanism of effluent mixing in a turbulent stream.

Detailed computer code work included the following items:

- The density current routines in the COLHEAT program have been tested with theoretical data and with McNary reservoir data. The results of a series of field studies in 1969 are being processed for a final report.
- COLHEAT and MAXPWR currently report evaporation (in Btu/ft²/day) and inches of water/day for each river section and the entire river system.
- Both COLHEAT and MAXPWR are fully operational under CSCX remote time sharing.
- Program documentation for MAXPWR is complete. Program documentation for the latest version of COLHEAT is still in process. These are being readied for a formal report.

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Thermal Effects Study
(W. L. Templeton, Ecosystems Department)

AEC-1, Performance of Thermally Shocked Young Salmonids
(C. C. Coutant, Aquatic Ecology Section)

Differential predation tests were completed for several durations of exposure of juvenile rainbow trout to 27°C (1.2, 2.5, 5, and 10 min), 25°C (3, 6, 12, 25, 50, 100 and 150 min), and 23°C (50 min). No recovery period was allowed in any of these tests. The series will be continued at lower shock temperatures until no effect can be observed. At 27°C, there was an apparent difference in predation after a 2.5 min exposure, while at 25°C, difference was apparent near 12 min. The 50-min exposures (all that have been completed at 23°C) show definite shock effect. There is mounting evidence that recovery is very rapid at the lower shock temperatures. Thermal resistance tests with equilibrium loss and death as endpoints have also been conducted for comparison with predation results.

AEC-2, Gas Bubble Disease of Young Salmonids
(M. J. Schneider, Aquatic Ecology Section)

The air injector system described previously yielded a maximum gas saturation of 115%. This degree of supersaturation is marginally capable of precipitating gas bubble syndrome, and this gas level could not be dependably maintained. A second method is now being employed in addition to air injection. Air equilibrated river water at 5°C is heated to 15°C, thus creating gas supersaturation. When fish acclimated to 15 C are exposed to this water, they quickly display symptoms of gas bubble disease.

Surgical techniques for Doppler flowmeter probe implantation were developed and perfected. A sham probe was implanted and allowed to remain in place for four days. At the end of that time the fish was sacrificed, and an autopsy showed that considerable healing had taken place.

The original Doppler probe obtained proved to be relatively insensitive and was returned for modification. In the interim two additional probes were built in this laboratory, one of which gave very encouraging results in preliminary tests.

Surveillance of the dissolved gases in the Hanford stretch of the Columbia River was scheduled to begin next month. Selection of several sites was based on field reconnaissance. These sites include the main stem of the river above, at, and below the reactor outfall. Additional sampling stations will be in the slough at a reactor site where there is a thermal seepage and in the White Bluffs slough where the water temperature is normally higher than in the river.

AEC-3, Sonic Tracking of Adult Salmonids
(C. C. Coutant, Aquatic Ecology Section)

A conference was held with J. H. Johnson, U. S. Bureau of Commercial Fisheries, Seattle, to plan for tracking studies in 1970. Temperature and pressure-sensitive sonic tags are expected to be available for use in July, August and September.

AEC-7, Relationship of Thermal Discharge to Food and Feeding of Juvenile Chinook Salmon
(C. D. Becker, Aquatic Ecology Section)

Analyses of basic data collected March through July continued.

AEC-8, Effect of Temperature on Fish Disease
(M. P. Fujihara, Cellular and Molecular Biology Section)

River temperatures increased 3°F at White Bluffs to 41°F during the past month. The number of fish with C. columnaris agglutinating antibodies has decreased to 12% and average titers to 1:4 due to lack of active C. columnaris infection. The incidence of fish with antibodies was 12% as compared to 37% last month. Fish were free of C. columnaris isolates for the first time since initial exposure to the disease in June,

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1969. The percentage of fish with furunculosis antibodies (29%) and the average titers (1:8) also decreased, but the presence of surface isolates (58.5%), and infected fish (17%) was high.

River temperature at the Wenatchee site was 37°F. Although temperatures at this site were generally several degrees lower than at White Bluffs during similar months, C. columnaris isolates and/or infected fish were found during each survey. No significant decrease in percent of fish with antibodies or in average titers has been observed since November 1969 when the temperature was 56°F. The percentage of fish with C. columnaris isolates, infection and antibody synthesis was 16%, 0% and 42%, respectively. Incidence of furunculosis isolates on fish (52%), infection (6.4%), and antibody synthesis (71%) has remained similar since the November sampling.

AEC-9, Effects of Increased Temperatures on Survival and Growth of Juvenile Steelhead

(P. A. Olson, Aquatic Ecology Section)

Juvenile steelhead exposed to approximate Columbia River temperatures and to added increments of 3, 4 and 5°F since early July experienced the yearly minimum temperatures during February, near 42°F in the warmest lot. Mortalities have been inconsequential since last Fall when most resulted from columnaris disease. Mortalities are not correlated with relative temperature conditions and range from a minimum of 4.0% in the 5°F increment to a maximum of 15.3% in the 3°F increment. Cold water temperatures continue to favor increased growth in the warmer lots so largest average fish are now in the 5°F increment (warmest lot) and smallest in the river temperature (coldest lot).

AEC-10, Temperature Tolerance of Aquatic Insects

(C. D. Becker, Aquatic Ecology Section)

Base river temperatures begin to rise from a winter low of 3.0°C during February. Temperatures in the artificial

channels receiving added heat in stages of 2.5, 5.0, 7.5 and 10.0 increased correspondingly. Bi-weekly samples for invertebrate drift entering and leaving the channels via the unfiltered water supply revealed little activity of insect larvae in the river proper. Samples from the channels indicate that winter recolonization by insect larvae had not occurred, despite thermal differentials between troughs. Some adult midges were observed ovipositing in the channel heated 5.0°C above base river temperatures in mid-February.

The design of a larger trough system and methodology of testing river invertebrates under different thermal regimes are under review for implementation.

Radiation Protection

(H. V. Larson, Radiation Protection Department)

A bioassay model for ^{242}Am and ^{243}Am was completed. Basically, the bioassay sampling schedule and the behavior of americium in the body is considered to be the same as for plutonium. Elevated initial urinary excretion of americium is expected, hence later excretion data (30 days) will probably provide the more accurate deposition evaluation.

Modifications of the polonium model to more closely fit the polonium excretion patterns observed at Hanford were completed. These modifications should permit final evaluation of pending polonium deposition evaluations. The polonium work at Hanford has been essentially completed.

Eighteen autopsy samples have been counted for americium on specially calibrated detectors at the whole body counter facility. Tissues counted include lung, lymph nodes, liver, spleen, kidney, heart, muscle and bone. An activity level of 0.85 pCi is detectable at 95% confidence for a four-hour count. Up to 4.3 pCi of ^{241}Am (right hilar nodes - perilymphatic tissue) has been found in these tissues.

A DUN employee was whole body counted using the large volume "quad" lithium drifted germanium detector. Europium-156 was easily detected at a level of 4% maximum permissible body

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burden. Europium-156 emits a complicated broad spectrum of gamma photons and was difficult to identify positively using the regular sodium iodide detector.

Routine annual reports summarizing 1969 exposure information for approximately 10,000 Hanford employees and 4,000 visitors were prepared and forwarded to AEC-RL. These reports included those required by AECM 0502 and by IAD 0525-19. Exposures above the limits given in AECM 0524 included a Class A radiation occurrence (1700 rem to the hand), a Class B occurrence (8 rem to the whole body), and a Class C occurrence (60 rem to the hand). One internal deposition case in excess of 50% of the maximum permissible body burden (MPBB) was reported for nuclides with an effective half-life of greater than 120 days. This involved an accumulated plutonium deposition of 55% MPBB incurred from several different intakes.

The 1969 results of uranium surveillance programs for two Hanford contractors were summarized and forwarded to appropriate radiation protection representatives. The data obtained indicated no buildup of insoluble uranium in the lung, as measured by in-vivo lung counting, and only occasional intakes of soluble uranium in excess of controls as measured by urine excretion. The maximum lung burden detected was 14 nCi (70% MPLB); however, this cleared readily to 3.5 nCi within six weeks. Other lung burdens detected were all less than 50% MPLB.

At the request of HEHF pursuant to an inquiry from AEC-HQ, exposure records for approximately 1100 deceased Hanford employees were reviewed for possible plutonium exposures during their employment at Hanford. A listing of those classified as plutonium workers (about 600), as defined by being on a plutonium bioassay schedule, and of those classed as plutonium deposition cases (14) was prepared and forwarded to HEHF.

There were 23 special bioassay and 11 in-vivo counter examinations conducted as a result of radiation occurrences. Special external exposure evaluations were performed for 15

Hanford contractor employees, primarily as a result of requests by contractor radiation protection representatives. There were no exposures in excess of the applicable limits. There were 5 new internal deposition cases confirmed by evaluation of bioassay data. Only one of these was in excess of 5% MPBB (evaluated as about 10%).

Recalculations were made of the output from the NBS calibrated PuBe neutron source and the Hanford standard PuF₄ source. For the PuBe source the recalculations were corrected to account for ingrowth of Am and other daughters and to utilize more recent flux to dose conversion factors. The recalculations resulted in a 15% increase in flux, approximately 30% increase in first collision dose rate, and approximately 15% increase in multiple collision dose rate. The apparent discrepancies between the two dose rates are resolved by noting that the new data used indicate a quality factor of 7.5 rather than 10 for the neutron spectrum from PuBe.

Spectroscopy of the heavily filtered X-ray spectra used for calibration purposes confirmed suspicions that the beam was not as homogenous as desired. A new series of graded filters were semi-empirically constructed using available materials and appear to provide an extraordinary degree of beam homogeneity consistent with reasonable output. Output has, of course, been greatly reduced by the addition of the graded filters, but the new result is a greatly improved energy spectrum with little low energy tail off or K characteristics radiation.

A watertight package using TLD-200 (CaF₂·Dy) with a 0.010 in. Ta plus 0.012 in. Pb filter to flatten energy dependence was prepared for Environmental Evaluations Section. Prototypes have been sent to the field for evaluation, and preliminary comments have been favorable.

The evaluation of the basic thermoluminescence dosimeter continues and the following results were noted. The response was evaluated over the range of 10 mR to 10,000 R. A minimum level of sensitivity of approximately 50 mR was indicated

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for the blocks, and a somewhat better sensitivity (~ 30 mR), for the Teflon disc. Supralinearity begins to occur at about 20 R but does not become significant until exposures of greater than 1,000 R are achieved.

The beta response of the dosimeters is, as expected on the basis of previous studies, approximately 0.5 that of the photon response on a rad per rad basis. Personnel wearing these badges in the field will have all the readings interpreted as if they were from photon exposure, hence providing a safety factor in the unlikely event of beta exposure.

Structural testing revealed a considerable weakness at the location of the numbers punched into the dosimetry card. In the fully assembled package sufficient strength is gained to minimize this negative effect. Some cracking was noted around the Teflon disc, but this should not interfere with the use of the dosimeter. Because of the construction of the cards, difficulty has been incurred in removing the Teflon discs. About half of the discs cannot be removed intact or are so covered with the plastic from the insertion card that they are virtually useless upon removal. Even those that are satisfactorily removed require the expenditure of a considerable amount of time--on the order of 3 to 5 minutes per dosimeter. The evaluation program with the Teflon discs is therefore being discontinued until an adequate method of removal is developed.

Precision of the badges was evaluated at a high and low dose level. A standard deviation of approximately $\pm 2\%$ at 5 R and $\pm 10\%$ at 90 mR was indicated. This precision is excellent and exceeds expectations.

The effects of relative humidity were studied and none were noted over a range of 10 to 95%. A study of several unrelated variables has been made and indicates that, at least for the reader annealed cards, there is a slight temperature dependence, no angular dependence, and no humidity dependence. Crushing the block was found to reduce light output per unit exposure by about 35%. No differences were noted between groups of badges with blocks crushed prior or subsequent to exposure.

Environmental Evaluations

(W. L. Fisher, Environmental Evaluations Section)

The January report mentioned that four ducks and one coot taken on or near the 100-K trench contained unusual quantities of P-32 and other radionuclides. Increased sampling in that area has produced no additional such birds. Although radiochemical analysis of the birds has not been completed, it is clear that the duck taken on the 100-K trench contained the greatest amount of radioactivity. The concentration of P-32 in the flesh of this duck was 0.11 microcurie per gram. Concentrations of other radionuclides ranged from one to several orders of magnitude below this figure. Since hunting on the Columbia River near 100-K has not been permitted, such a duck could be taken only while feeding or migrating at some distance (from several to several thousand miles) from 100-K. Radioactive decay of the P-32 in the time period between the duck's feeding near 100-K and the duck's being eaten would likely cause significant reductions in the human exposure potential of such a bird. The sampling of ducks and the environs near 100-K will continue periodically in order to define the problem better.

A special shoreline survey, part of the analysis of the Columbia River upstream from 100-F, was performed between the 100-B and 100-F on February 1, 1970, where the river flow rate is about 40,000-45,000 ft³/sec. Generally, the plant shore and islands showed greater contamination levels and exposure rates than the far shore. Shoreline contamination levels and exposure rates were not significantly different from those observed last Fall between 100-F and Ringold.

Regional fallout levels remained at approximately 0.1 pCi/m³ beta, the same concentration as last month and the same period one year ago.

Special soil samples were obtained for plutonium analysis from several locations on and near the Hanford reservation.

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In general environmental levels of radioactivity were consistent with previous experience and indicated no unusual sources of exposure to the population or environs.

Meteorological Services

(E. H. Phinney, Synoptic Meteorology Section)

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

FEBRUARY 1970

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