AECD-3817

RADIOLOGICAL SCIENCES DEPARTMENT
QUARTERLY PROGRESS REPORT
RESEARCH AND DEVELOPMENT ACTIVITIES
OCTOBER - DECEMBER, 1954

By

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RADIOLOGICAL SCIENCES DEPARTMENT

January 10, 1955

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

Operated for the Atomic Energy Commission by the
General Electric Company under Contract #W-31-109-Eng-52

RESTRICTED DATA

Date Declassified: December 7, 1955

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RADIOLOGICAL SCIENCES DEPARTMENT

QUARTERLY PROGRESS REPORT RESEARCH AND DEVELOPMENT ACTIVITIES OCTOBER - DECEMBER, 1954

I. INTRODUCTION

This twenty-first quarterly report of the research and development activities of the Radiological Sciences Department, Hanford Atomic Products Operation, as before, includes some items charged to control but included for general interest. Such are identified as "not charged to research."

The previous report of this series was numbered:

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II. PERSONNEL

	Biology Section			Biophysics Section		
	9/30	12/31	Net Increase	9/30	12/31	Net Increase
Supervisors	8	8	0	6	5	-1
Scientific and Technical	27	26	-1	32	31	-1
Non-Technical	20	17	-3	6	5	-1
Clerical	8	8	0	3	2	-1
Total	63	59	-4	47	43	-4

III. LABORATORY FACILITIES

Facilities for particle inhalation experiments on small animals were completed. Approval was received and design started on facilities for extension of this work to larger animals.

IV. RESEARCH AND DEVELOPMENT PROGRESS - BIOLOGY

(H. A. Kornberg - Manager)

A. Aquatic Biology (R. F. Foster)

Biological Chains

Inactive.

Absorption of Tritium by Aquatic Organisms (R. F. Foster)

No results.

Radiobiological-Ecological Survey of the Columbia River (J. J. Davis, C. C. Palmiter, D. G. Watson)

The activity density of most river organisms declined from maximum levels reached in September. Average values at the end of the quarter for Hanford were: 2×10^{-3} μc/g of minnows (shiners), and 8×10^{-3} μc/g of caddis larvae. The activity density of plankton increased to 3×10^{-2} μc/g which is normal with diminishing river flow. Radioactivity levels were generally the same as those for the same period in 1953.

An upstream movement of whitefish coincident with spawning and appreciable angling by sportsmen was again apparent since radioactive specimens were abundant at Priest Rapids, upriver from the reactors. Table I summarizes the activity densities observed in whitefish during the quarter.

TABLE I

ACTIVITY DENSITIES OF WHITEFISH FLESH

Collection Site	Average μc/g	Maximum μc/g
Priest Rapids	2×10^{-4}	1×10^{-3}
Immediately below reactors (No public fishing)	6×10^{-4}	3×10^{-3}
Ringold	2×10^{-4}	(2 specimens only)

The activity density of whitefish is almost identical with that found last year.

A total of 157 salmon nests was observed within the Hanford reservation, compared to 292 in the parent year of 1950. The reduction was anticipated since this year's fall run of chinook salmon over Bonneville Dam was the smallest on record.

Midge larvae living in the silt accumulating behind McNary Dam reached a maximum activity density of 9×10^{-4} μc/g in September. This level diminished to 2×10^{-4} μc/g in December which was similar to that observed in 1953.

Effect of Reactor Effluent on Aquatic Organisms (Not charged to research) (P. A. Olson, R. F. Foster)

Routine monitoring of reactor area effluent water was resumed on November 4 with the subjection of chinook salmon eggs (Puget Sound strain) to the following effluent concentrations: 0%, 1%, 2%, 3%, 5%, and 10%. Temperatures were adjusted to match the corresponding theoretical temperatures which would result in the river at the indicated temperatures. The mortality of eggs in the 10% strength effluent was 25% - about twice that of the controls. Significant effects are not yet apparent in the weaker concentrations.

A test was also started with chinook salmon eggs to determine the toxicity of dicaromate, a corrosion inhibitor added to the process water. The eggs were incubated in the following conditions: dichromate free water from above all reactors, Columbia River water with nominal dichromate content from reactors upriver from the laboratory, and 0.02, 0.04, 0.06, 0.1, 0.2, and 0.5 ppm of sodium dichromate. All of the egg lots hatched without abnormal mortality. Previous experience suggests that significant mortalities may be expected in the fry stage, however.

B. Experimental Animal Farm (L. K. Bustad)

Toxicology of I^{131} (L. K. Bustad, L. A. George, S. Marks, P. L. Hackett, N. L. Dockum, E. J. Coleman)

During a regular six-month testing period of representative numbers of experimental and control animals, significant deviations from normal values were found in certain of the blood constituents among the 1950 offspring of the original 5 μc/group (Table II).

TABLE II

BLOOD CONSTITUENTS (MEAN VALUES) IN FOUR-YEAR-OLD EWES (3/2/54 TO 8/3/54 - TEST PERIOD)

Constituent	1950 Offspring		
	5 μc/day Group	Control Group	Avg. Difference between Groups (at 99% confidence limit)
PBI (μg/100 ml)	3.34	4.25	1.91 ± 0.23
Leukocytes (cells/cu mm)	7,710	9,220	1510 ± 450
Lymphocytes	4,280	5,410	1150 ± 380

Depression in values noted are considered biologically significant. The mean value for protein-bound iodine, although considered in the lower range of normal values, is indicative of a marginally hypothyroid condition.

A study designed to ascertain the specific effect of surgical thyroidectomy on certain blood constituents in order to furnish sound basis for a comparison with values obtained after thyroid ablation by I^{131} was completed. Values for creatinine, inorganic phosphorus, urea nitrogen and neutrophils increased, while leukocyte and lymphocyte counts decreased. Cholesterol was found to be lower in the experimental animals than in the controls until 120 days after thyroidectomy, while calcium values were lower after this period.

In order to compare the effects of acute and chronic administration of I^{131}, an experiment was performed in which single doses of 5 or 15 mc of I^{131} were administered to each of eight animals. Depression in lymphocyte count, serum protein-bound iodine values and reduced effective I^{131} half-life in the thyroid gland were observed in the 15 mc level only. Pathologic observations suggest that the thyroid gland would be essentially destroyed by 15 mc while the gland in an animal receiving a single 5 mc dose would still possess much functional tissue.

Whole Body X-Irradiation of Sheep (L. A. George, P. L. Hackett, L. K. Bustad)

A pilot study was conducted to determine the response obtained in sheep after bilateral whole body irradiation from soft x-rays. Exposure levels ranged from 300 to 900 r employing an x-ray unit operated at 250 KV, 30 ma. Lethargy, depression, weight loss, alopecia, anorexia, and inhibition of clot retraction was observed following 750 and 900 r. In addition a severe lymphopenia was noted at all exposure levels.

No deaths occurred that were attributable to x-irradiation during the first two months following exposure.

Irradiation of Pig Skin (L. A. George, J. W. Healy*, L. K. Bustad)

Twelve sites on three pigs were exposed to radioactive particles mounted between lucite discs and mica. Exposures ranged from 200 to 12,000 microcurie-hours (principally Ru^{106}) delivered in 27 hours. Results ranged from a slight erythema at the lowest exposure to severe inflammation and necrosis at the high levels.

C. Metabolism (R. C. Thompson)

Plutonium Absorption and Metabolism (M. H. Weeks, W. D. Oakley, R. C. Thompson)

Percutaneous absorption of plutonium (10 N HNO_3 solution) was compared in rats with intact skin and with punctured skin (spring-lancet). No significant differences were noted.

Preliminary results suggest that G. I. absorption of plutonium fed as a pH 1 Pu (IV) nitrate solution may be as much as 20 times greater than absorption from similar pH 2 or pH 4 solutions.

Fission Product Absorption and Metabolism (M. H. Weeks, W. D. Oakley, O. L. Hollis, B. Kawin, R. F. Palmer, R. C. Thompson)

Percutaneous absorption of ruthenium was measured in rats using 2 N and .01 N HCl solutions. Absorption was approximately tenfold higher from the more acid solution, with a maximum of 5% absorbed in a 24-hour period. Absorption of ruthenium from "particles" held against the skin for a period of 24 hours was extremely variable, with a maximum absorption of 0.1%.

Rats maintained for 71 days on drinking water containing MPC levels of Ru^{106} (0.1 μc per ml) were receiving, at the end of the period, radiation to kidney 50 to 70 times in excess of the permissible dose.

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*Biophysicist, Radiological Engineering Section.

Retention of ruthenium in rats is being studied following chronic oral ingestion and acute i.p. injection. Preliminary results from these experiments suggest that bone may prove to be the critical organ in ruthenium exposure.

Eighteen rats were fed "particles" to determine absorption of ruthenium from the G. I. tract, and 36 rats were fed particles to study the duration and extent of holdup of the particles in the G. I. tract. Absorption results varied widely with an average value of about .01%, or approximately 1/100 of that observed when soluble ruthenium is fed. These data were reasonably compatible with solubility measurements of particles in simulated body fluids. One out of 36 rats showed substantial retention of ruthenium in the G. I. tract beyond 72 hours after feeding. The purpose of this test was to scope, in a provisional way, the troublesome question of retention of such particles in the human case.

Ruthenium in the blood is present almost entirely in the plasma and seems to be associated with specific protein fractions.

Tritium Absorption and Metabolism (R. C. Thompson, J. E. Ballou)

Contrary to previous indications, there appears to be no effect of the level of tritium irradiation on the incorporation of tritium into tissue compounds.

D. Pharmacology and Experimental Therapeutics (R. W. Wager)

Plutonium Toxicity and Therapeutics (R. W. Wager, L. A. Temple)

Inactive.

Radioactive Particles, Metabolism and Toxicology (R. W. Wager, L. A. Temple)

Attempts to determine the absorption and distribution from the lung of ruthenium in $Ru^{106}O_2$ particles intratracheally administered to mice were unsuccessful. Improvements in monitoring methods to trace radioactivity in the living organism are being made to expedite this study.

Mice were intratracheally injected with $Ru^{106}O_2$ particles plus subthreshold amounts of dibenzanthracene to determine whether the two substances will act synergistically in inducing pulmonary tumors. Also, employing the ears of rabbits, studies are underway to allow observations of dermal synergism.

E. Plant Nutrition and Microbiology (F. F. Hungate)

Plant Nutrition (J. H. Rediske, J. F. Cline, A. A. Selders)

Studies by the Neubauer technique gave concentration factors for Ba^{140} of 0.32 for sandy and 0.13 for silty clay soils. In nutrient solution tests, a concentration factor of 0.10 was obtained for the carrier-free Ba^{140}. Addition of carrier up to 0.1 μg Ba/ml of solution increased the uptake. These values are in the same range as those obtained for strontium and indicate that Ba^{140} is a fission product of potential hazard to crops during the first year after fission.

Using the Neubauer technique a concentration factor of 0.0013 was obtained for Pm^{141}. Tc^{90} was also tested, but its specific activity is so low that severe toxic symptoms intervened at low activity levels.

Both the starch and sugar concentrations increased in bean plants grown in nutrient solutions containing up to 10 μg Cr^{+6}/ml. Additional chromium reduced the starch and sugar concentrations in the plants. No more mutations were found in barley irrigated for two years with 5% and 100% reactor effluent than that irrigated with well water. This is as anticipated, since the activity densities of the barley from all plots are essentially the same.

Although it had been anticipated, from the reduced yield, that chromium concentrations in the 100% effluent plots had increased over those found last year, spectrochemical analyses of soil failed to identify any increase. Sampling errors or diffusion of the chromium may account for this.

RBE by Microbiological Methods (H. J. Dishburger, F. P. Hungate)

Tentative RBE values of 1.8 for diploid and 2.3 for haploid yeast were obtained in comparing tritium with P^{32} radiation. Several methods of preventing adsorption of polonium to yeast cells were tried, but none was successful.

Genetic Effects of Internally Deposited Radioelements (F. P. Hungate, W. J. Bair)

In a preliminary experiment to measure the transmutation effects of S^{35} on yeast, the cells were held in a refrigerator to inhibit growth during internal irradiation. However, the constant stirring by a magnetic stirrer destroyed almost all cells. Additional tests are under way using both lyophilized and frozen cultures to hold the cells through a longer portion of the 80-day half-life of S^{35}.

F. Minor Problems

Biological Monitoring (Not charged to research) (W. C. Hanson)

Rabbit thyroid activity densities increased five-fold over the mean of the previous quarter, with maximum values as great as 1×10^{-2} μc/g of tissue, from animals collected near the Separations Areas. A twofold increase similarly occurred in feces activity densities with a maximum value of 2×10^{-4} μc/g.

Waterfowl on the Columbia River contained 5×10^{-4} μc per gram of edible tissue. In coots frequenting a swamp containing radioactive wastes, activity densities of 2×10^{-2} μc (presumably cesium) per gram muscle tissue were observed. Puddle ducks taken from the same location contained about one-fifth as much activity.

V. RESEARCH AND DEVELOPMENT PROGRESS - BIOPHYSICS

(D. W. Pearce - Manager)

A. Monitoring Methods

1. Analytical Techniques (J. M. Nielsen)

Electrodeposition Methods for Plutonium (R. W. Perkins)

In a search for a rapid method for isolating plutonium from urine in a form suitable for electrodeposition, it was found that Dowex 50 x 8 resin could quantitatively remove plutonium from acidified plutonium-spiked urine. One gram of the resin stirred for 10 minutes with 50 ml of the urine was found to remove 90% of the plutonium at room temperature. Yields as high as 90% were obtained by raising the temperature of the system to above 90°C. Optimum acid concentration for this process was found to be 0.3 N nitric acid. Success in this field would greatly simplify the tedious bio-assay separation of plutonium.

Continuous Monitors for Reactor Effluent (H. G. Rieck, J. D. McCormack)

A monitor for continuous monitoring of the total beta component in reactor cooling water was designed and a prototype was fabricated. This monitor employs an aluminum strip which is advanced through the monitor components. Sample dishes are pressed into the strip and filled with the reactor water sample from a pipetter which is kept supplied with fresh reactor effluent water. The sample is dried while resting on a heater below the pipetter and is moved under a proportional counting tube on the next cycle and the counting rate recorded automatically. The monitor was designed to cycle a sample in 10 minutes. Preliminary testing is essentially complete.

Problems in Radiochemical Analysis (R. W. Perkins, H. G. Rieck, W. B. Silker, R. J. Walker)

A gamma ray spectrometer method of determining the activities of Ru^{103} and Ru^{106} in mixtures of these isotopes was successfully developed.

Gamma ray spectrometer traces of these isotopes show peaks at 0.51 and 0.62 Mev. The ratios of the heights of these peaks were found to be related to the amounts of the isotopes present. Calibrated mixtures of these isotopes were used to obtain a curve from which the Ru^{103} and Ru^{106} values could be read using the peak height ratios obtained on any sample mounted in a standard manner. This method is non-destructive of the sample and measurements were made on solid sources needed intact for other investigations. Standard deviation measurements made on calibrated solutions showed this method to be reliable within 3% for 100% Ru^{106}, 6% at 100% Ru^{103}, and 2-6% for mixtures.

A procedure was developed for the determination of Zr^{95} and Zr^{97} in reactor effluent water which isolates the mixed isotopes in a yield of about 80% and in a state of high radiochemical purity. The procedure is based on the ability of thenoyltrifluoro-acetone-benzene solutions to extract zirconium without other contamination from aqueous solutions of high nitric acid content. A preliminary TBP-benzene extraction is used at present as a purification step. The Zr^{95} and Zr^{97} are differentiated by decay counting.

Excellent decontamination was effected in the procedure for the determination of As^{76} in reactor cooling water by a gross cation contamination removal on Dowex 50 x 8 with the arsenic present as arsenate ion. Subsequent purification resulted from an arsenic sulfide precipitation from the solution containing arsenic as arsenite ion. The sulfide precipitate was dissolved in mixed acids and As^{76} as the metal was precipitated and counted. No radiochemical contamination was observed. The yield was 97% with a standard deviation of 3.7%.

Rates of Solution of Particulate Material (D. R. Kalkwarf)

Dissolution rate studies of particulate waste material containing radio-ruthenium were made in synthetic gastric and alveolar fluids at 37°C as a part of the hazard evaluation study of this material. Less than

8% of the radio-ruthenium was found in solution after one week in all but one case of the 14 particles studied. In that single case 21% of the activity was in solution after one week. The dissolution rate at one week was in all cases less than 0.5% per day. Due to the large variation between individual particles, it was not possible to distinguish any difference in the action of the two fluids. Due to the large variation between individual particles, it was not possible to distinguish any difference in the action

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of the two fluids.

2. Gamma Ray Dosimetry (W. C. Roesch, H. V. Larson, I. T. Myers, J. S. Reddie)

Looking forward to an improved system for detecting and measuring ingested radio-isotopes, a larger scintillation counter was obtained for testing purposes. Tests on people placed before this counter confirmed the experience with an earlier, smaller counter, namely that the amount of local background blocked out varies with the individual. Since this would make reliable measurements of small amounts of radioactivity quite difficult, various types of extra shielding were studied. Concrete was very poor because it increased the background considerably. It now appears that water may make a suitable shield.

The use of scintillation counters for the detection of x-rays from plutonium was investigated and shown to be applicable to the measurement of plutonium in mice. A NaI(Tl) crystal 1/3 inch thick was used; the small volume cut down background but detected all the soft x-rays. Due to the strong absorption of these rays, even in tissue, errors of as much

increased intensity to as much as 20 r/hr. Since precise electrode movement at the small spacings required would be difficult, a vacuum chamber is being fabricated to surround the extrapolation chamber so that the air between the electrodes can be removed, thus effectively bringing them closer together.

L. V. Spencer of the National Bureau of Standards recently proposed a modification to the Bragg-Gray theory of cavity ionization which would be extremely important, if verified, in many of the extrapolation chamber measurements. Existing experimental evidence on the matter is conflicting. A special set of electrodes was prepared to be used in the vacuum chamber mentioned above to test this theory.

3. Beta Ray Dosimetry (W. C. Roesch, E. E. Donaldson)

A special extrapolation chamber for measuring the dose rate from particles or fine beams of radiation was built to assist in biological experiments. The chamber has several concentric collecting electrodes from 0.2 to 5.0 cm in diameter. Over the thin accelerating electrode is stretched another thin membrane mounted on a ring which can be moved in the plane of the membrane; a particle can be mounted on this and positioned accurately with respect to the chamber. Measurements of particles being used by the Biology Section are in progress.

The disc-shaped chamber proposed as a substitute for the CP chamber to permit accurate measurement of beta and gamma surface dose rates was under adaptation to a field instrument by the Instrument Development Unit. Tests of the ability to measure contact beta ray dose rates such as those from uranium showed that the chamber required only a small correction factor and that by a series of measurements at different distances from a surface and extrapolation to zero separation, accurate measurements could be made.

4. Neutron Dosimetry (W. C. Roesch, J. DePangher)

Relatively minor difficulties such as a poisoned palladium leak in the ion source and a shorted high voltage transformer continued to delay work with the positive ion Van de Graaff, but several periods of normal operation were obtained. Targets of lithium fluoride, beryllium, and tritium-zirconium were used successfully.

Data on the efficiency of moderated slow neutron detectors versus thickness of paraffin or lucite moderator are being gathered for various neutron energies to permit design of new instruments with improved fast neutron dosimetry properties. Data are essentially complete for 160 Kev and 500 Kev and for neutrons from a polonium-boron source as taken with a BF_3 counter. A few checks have been made of indium foil activation; it was found to be proportional to the BF_3 counting rate. The standard Hanford moderated BF_3 counter is 5.3 times more sensitive (per unit dose rate) to 160 Kev neutrons than it is to the neutrons from the polonium-boron calibration source.

The polonium-boron neutron source of the Calibrations Unit was calibrated against the radium-beryllium standard by the water tank method. The results agreed with comparisons made with the sigma pile and the long counter. These methods had been subject to the criticism that they were not known to be independent of the energy spectra of the sources; the water tank is theoretically almost completely independent of such energy differences.

B. Environmental Studies and Adequacy of Waste Disposal Systems

1. Atmospheric Contamination Studies

Stack Gas Particulates (R. H. Scott, F. E. Adley)

Study of the physical characteristics of radioactive particles obtained from local ground surfaces was continued. Dimensions and dosage rates were measured for 29 particles, 22 of which were also

weighed. The effective diameters ranged from 175 to 1200 microns, the dosage rates from 0.15 to 25.5 rads/hr and the weights from 4 to 1420 micrograms. Twenty were retained for density and terminal settling velocity measurements. A lucite jig was developed for use in radio-autographing particle specimens to be used by the Biology Section in skin damage experiments. Forty-three particles were mounted and radio-autographed in this manner and 34 were found to be suitable point source specimens.

Respirator Testing (W. E. Gill, F. E. Adley)

The study of the effectiveness of respiratory devices used against ruthenium-contaminated atmospheres continued. The penetration of MSA type H cartridges and the red (E4R5) and gray (M-11) assault mask cartridges by ruthenium scrubber off-gas contamination was less than 0.01%. The penetration of MSA cartridges by cell atmospheres ranges from 2% to 8%. The two assault mask cartridges had penetrations of almost 1% and the MSA all-service canister showed less than 0.1% penetration. Leakage tests conducted on assault mask cartridges showed that at 3" water static pressure, 3 of 11 used gray cartridges leaked. No leakage was evident with red cartridges.

A new plastic air-supplied hood was tested as a possible replacement for air-supplied masks in certain hazardous atmospheres. Penetration tests showed a lack of protection up to 11 cfm of supplied air, the maximum tested, with accompanying excessive air pressure requirements. These factors and other deficiencies such as poor design and construction materials resulted in the recommendation that this device should not be used in hazardous atmospheres.

Incidental Studies (W. E. Gill, J. W. Baum)

To determine if the discharge of oxides of nitrogen by separations processes presents a health hazard requiring control, several spot samples were collected in the stack environs by means of a recently developed field sampling method. Five samples collected at ground level under adverse meteorological conditions showed an average concentration of about 70 ppm and a peak concentration of about 100 ppm.

2. Experimental Meteorology

Statistical Studies of Diffusion (200 Mile Scale)

No significant work was completed during this quarter.

Diffusion Experiments (J. J. Fuquay, B. Shorr, M. F. Scoggins)

Nineteen fluorescent pigment drum samplers were received during the period and final plans and preparations for the use of fluorescent pigment as a tracer in diffusion experiments were completed. A TIFA fog generator, capable of emitting a mixture of oil and pigment at controllable rates, was installed at the 183 foot level on the Meteorology Tower. In order to provide continuity from previous experiments, the oil fog emitted by the generator was calibrated according to the fluorophotometric technique. This calibration showed good agreement with the calibration obtained with the Army M-2 smoke generator for three out of four emission rate settings on the TIFA generator. The inconsistency on the fourth setting was not explained.

Wind Tunnel - Particle Pickup (G. R. Hilst, P. W. Nickola, B. Shorr, M. F. Scoggins, J. J. Fuquay)

An intensive program of field experiments, designed to study the processes of particle pickup and the relative efficiencies of various surfaces in retaining small particles, was undertaken. The first of these experiments included observations of airborne concentrations and deposition of small fluorescent particles initially deposited on a circular source area, twenty feet in diameter, located in a region of sand and sagebrush which may be considered representative of much of the Hanford Area. This source was found to be seriously depleted following two days of strong wind (speeds 15-25 mph), indicating that the natural surface characteristic of much of this area is highly erodible and that particles deposited on this surface are susceptible to subsequent translocation during periods of strong winds. (This observation is substantiated by visual observation of flowing dust during these periods.) The second experiment was devoted to a study of the relative retentive efficiency of grass covered, rock covered, furrowed, and snow-fence protected surfaces. Preliminary analyses of the data obtained from this experiment indicated that the rock-covered and the grass-covered surfaces retained particles equally well. The furrowed surface retained particles very poorly when compared with the grass or rock-covered surface. The best particle retention was observed in the immediate lee of the snow fence but this result was somewhat suspect since this source was shaded from the sun and was noticeably wetter than the others.

The dc counting rate meters for the light-chopper anemometers were received and installation was begun. Five mil copper constantan thermocouples were received from fabrication and calibrated. Tests to determine the effect of solar radiation on these thermocouples were conducted.

Diffusion - Emergency Conditions (M. F. Scoggins)

Analysis of the wind velocity data collected from the meteorological wind stations continued on a routine basis.

Analyses of 690 forecasts of wind direction at the various wind station sites, using the wind direction at the Meteorology Tower and the wind predictor system showed a verification of 73%

Research - Micrometeorology (G. R. Hilst, J. J. Fuquay)

The design information for the UCLA shear stress meter was submitted to the Instrument Development Unit for appraisal, suggested modification, and cost estimates. This instrument, which measures the shearing stress exerted on the ground surface by the wind, is being considered as a valuable adjunct to the portable mast.

3. Ground Waste Investigations

Ground Water Studies (J. R. Raymond, P. P. Rowe)

Dilution-velocity tests continued, in which the dilution rate of tracer materials in drilled wells was measured by means of electrical conductivity apparatus. Rates of movement of the ground water through the wells were thus calculated. The rates of movement so determined corresponded to the various geologic formations and their different permeabilities and indicated the correctness of the geological data there as well as orders of magnitude of the ground water flow rates. The tests provide a concrete basis for estimating travel times of potential radioactive contaminants in the ground water from operating areas to the Columbia River and indicate sites where control is adequate.

Waste Disposal Field Investigations, Area 1 (J. R. Raymond)

Monitoring of new test sites was begun to determine the moisture-holding capacity (specific retention) of the ground. Measured volumes of liquid containing various non-radioactive salts and radioactive isotopes were discharged to test sites and the ground water beneath those sites

sampled and analyzed daily to determine the first breakthrough of water (evidenced by non-radioactive salts) and the time lag between breakthrough of those salts and the radioactive isotopes. Breakthrough of neither was detected, indicating the existence of a column of effective size larger than previously estimated, hence a greater capacity for storage of water per disposal unit and a total exchange capacity and consequent safety factor greater than formerly believed.

Waste Disposal Field Investigations, Area 2 (J. R. Raymond)

Contamination of the ground water in a third test site was explored and evaluated. Careful depth sampling during the work showed no evidence for gross settling of the contaminants in the ground water but rather a strong preference for concentration at the ground water surface. This whole question of vertical travel of contaminated water on ground water needs further study as there are some agreements for its descent under gravity. This has never been found at Hanford.

Waste Disposal Field Investigations - Reactor Areas (J. R. Raymond, P. P. Rowe)

Dilution-velocity tests were conducted in sites of mutual concern to Areas 1 and 2 and to the reactor areas in connection with the feasibility studies for the routine discharge to ground of large volumes of reactor coolant.

General Geologic Studies (R. E. Brown, J. R. Raymond, M. W. McConiga)

About nine square miles on the west side of the project were intensively mapped to determine the sequence and structure of bedrock formations beneath the plant areas.

Careful instrumental leveling in the White Bluffs' section of the Ringold formation clearly indicated deformation subsequent to deposition and consequently, considering the more recent age of that formation as now determined, a shorter period since deformation and a somewhat greater earthquake potential than previously believed.

Laboratory Studies (D. W. Rhodes, J. R. McHenry, K. R. Holtzinger)

Equilibrium adsorption of Pu by soil from 0.5% Hilco Triple Strength Cleaner solutions (a sodium phosphate decontaminating agent) was irregular and dependent on the pH. The adsorption of Pu was only 12% from 1 M $NaNO_3$ solution at pH 7.5. Equilibrium adsorption curves for other fission product cations varied. Cs was readily removed from 1.0 M $NaNO_3$ solutions when the pH was above 7.0, but decreased below that pH. Sr adsorption from similar solutions dropped sharply as the pH was lowered, from 95% at pH 11.3 to 75% at pH 9.7 to none at pH 6.0 and less. Routine disposal of decontamination solutions to ground is clearly inadvisable.

Adsorption of Sr by soil from a synthetic "low-acid" process waste solution was low, breakthrough occurring in less than one column volume. The presence of phosphate in the solution, however, increased the adsorption of Sr markedly. Removal is due in part to the formation of phosphate precipitates when the phosphate concentration is >2 g/liter and the Sr concentration is about 5×10^{-6} g/liter. Sr removal is probably primarily due to adsorption, however, when the Sr concentration is $<5 \times 10^{-7}$ g/liter. Soil column adsorption studies, conducted with a "scavenged" plant waste disclosed that a decontamination factor for Sr >300 was obtained for two column volumes containing <1 μc/ml of Sr and at pH >9.

C. Intrumentation for Radiation Detection and Measurement

Survey Instrumentation (D. A. Campbell, R. A. Harvey, M. O. Rankin W. G. Spear, L. D. Test, L. V. Zuerner)

One channel of the combined beta-gamma and alpha hand and foot counter was assembled with a sample probe and was tested with good results. The instrument will indicate whether contamination is or is not present and, if the former, on which surface it is located by the use of appropriate lights.

A doorway monitor to detect particle contamination on the clothing of personnel was designed, assembled, tested, and installed in an area badgehouse. Photomultiplier tubes with a thin anthracene scintillator were used for the detectors. To obtain wide angle sensitivity, the scintillator was applied to a lucite hemisphere in turn attached to the photocathode of the photomultiplier tube. The sensitivity to radiation parallel to the photocathode was increased by the latter arrangement by a factor of four, while the sensitivity perpendicular to the photocathode was unchanged.

An improved model of the TP portable high level beta-gamma survey instrument was designed using three ranges (0 to 5 r/hr, 0 to 50 r/hr, and 0 to 500 r/hr).

A portable G-M instrument was designed incorporating all recent feasible suggestions. The instrument will utilize a thin wall 30 mg/cm^2 in a rugged probe with outside range calibration potentiometers and with a flyback high voltage power supply.

Biological Instrumentation (D. A. Campbell, L. D. Test)

A counter was designed for the Biology Section for counting and locating radioactive particles and aerosols in the bodies of mice. The system will allow both gross body measurements and collimated measurements for location of the isotope. The problem of positional error will be alleviated partially through the use of an array of three detectors (NaI crystals on 6292 photomultipliers) located 120 degrees apart around the sample. A lead shield was designed to surround both sample and detectors, and further background reduction was accomplished by the use of a pulse height analyzer set to pass only those pulses in the characteristic photo-peak of Ru^{106}. Fabrication was started.

Laboratory Instrumentation (D. A. Campbell, M. O. Rankin)

An automatic sample changer was designed which will hold fifty samples in an interchangeable rack. In use, a sample from the rack will

be transported into the pig, counted for a predetermined time, and returned to the rack. An automatic camera will record the count, sample number, and time and date of counting. Fabrication was started.

A high speed decade scaler was developed which employs three EIT decade counting tubes and an electrically reset Sodeco register. The latter counts once for each one thousand counts at the scaler input and is limited to twenty counts per second therefore the maximum counting rate of the scaler is twenty thousand counts per second.

Special Purpose Instrumentation (G. E. Driver)

The development part of the Control Station for the Radio Telemetering System was completed and models were assembled and placed under continuous test. Some installation cost estimates were obtained in order to provide a basis for estimating the cost of the completed system.

The river bed temperature measuring probe was recalibrated and subsequently placed in a salmon nest in the Columbia River.

River Studies (R. E. Rostenbach)

The Columbia River survey involving ten traverses of the river between plant area and McNary Dam was started; that phase of it to establish present backgrounds and to predict certain hydraulic and physical characteristics of the river water in areas of special interest was completed. Radioactivity levels and surface water velocity were determined; river depth was determined by means of the Fathometer and certain temperature determinations were made by the use of the Thermarine. In general, previous observations were confirmed in that the radioactive materials tended to cling near the plant shore.

Temperature determinations made in December at McNary Dam by the use of the Thermarine confirmed the observations made in November. There is no significant difference in the water temperature between the surface and near the bottom at ten locations across the reservoir; the same was true well upstream from the head of the lake.

VI. SUMMARY AND STATUS OF THE RESEARCH PROGRAMS

As presented in the 21 issues of this report to date, the research and development activities are a conglomerate of apparently unrelated work accountability abstracts from a wide variety of scientific disciplines.

Essentially all the work is done in close support of the solution of existing or foreseen radiation problems at the Hanford Works. Characteristically each practical problem is attacked simultaneously in each component of appropriate scientific discipline. To detail the quantitative connections would involve some discussion of production amounts inappropriate for the wide circulation that this report has. However, it is now felt that the report series would seem to have more purpose and direction if some examples of the integration of the study elements were occasionally given. Such examples follow.

Emission of highly active ruthenium particulate matter from separations plants has caused redirection of program in all except one of the research units. Obviously, all the biological work on ruthenium particulates is in support of this phase. The findings are valuable and disturbing,

as for example in showing the need for revision of Handbook 52 limits by a factor of about 100. In addition, biophysics work includes particle size and nature characterization, tests of respirator efficiency, detection of ruthenium in the bodies of man and animals, survey equipment for roads, vehicles and exit gates, determines of Ru^{103}/Ru^{106} ratios to establish particle age, solubility of particles in simulated body fluids, dosimetry of particles in skin contacts, stack gas monitors specific for ruthenium, atmospheric transport of large particles, pickup and redistribution of particles on the ground, methods of collecting or trapping such particles, and the behavior of ruthenium in soil or ground water. At the present time, the predominant features of the particle problem appear to be well covered by the short term studies. Some phases can only be answered definitively by long term work that has been started.

The increased incidence of internal deposition of radioelements in personnel as the plant ages is another typical problem requiring timely redirection of the studies to have the best available measurement techniques, preferably by external monitoring. This avenue will be noticed in physics, methods and instrument development reports, and will become increasingly prominent.

The use to which earth sciences results are put is generally obscured in the work abstracts. The technical data are developed further by the Radiological Engineering Section and made available for engineering application at the earliest opportunity. Generally in the last year the results have favored more generous disposal of wastes, with savings of several million dollars. More recently, some adverse findings have led to late changes in plans. It is obvious that the future operating plans call for more rapid development of the ground water data in order to maximize savings if additional storage tanks are not indicated or assure wise expenditures if they are needed.

In the process of establishing more rational bases for permissible limits of specific nuclides substantial progress has been made. The handling of tritium is essentially fully scoped, with important findings on R.B.E. and on long term retention in some tissues, both of which amplify the hazard by factors of two over the elementary calculations.

All the data on plutonium uptake through the gut in this laboratory indicate that the permissible limit can be safely raised by a factor of 10 (actually 40 from the data). The opposite finding for ruthenium isotopes has been mentioned already. We are following the general policy of scoping the uptake parameters in small animals, usually the rat, and testing the results in a large animal such as the pig. Where there is agreement between those two sets of data, more confidence is given for human application.

The uptake of P^{32} is receiving particular attention. There is a discrepancy between the internationally accepted value and that derived from NBS Handbook 52 principles which involves a useful factor of 4. Since the local interest arises from consumption of fish flesh a direct test of such uptake is being made. In addition, the influence of bone growth may be critical in this case since children can be exposed. This factor is also being examined.

The principal atmospheric contaminant at this site has been I^{131}. The effect of this agent on grazing sheep has been determined with sufficient accuracy for control purposes. Needed also are similar data for an animal not a ruminant; the pig is being used. Also the uptake by man, eating fresh garden produce and drinking milk from cows on an I^{131} contaminated range sets a limit quite close to that appropriate for sheep. In all these cases, the vegetation limit is such that acceptance of the I^{131} limit for human breathing as in Handbook 52 could lead to disastrous overexposure.

Gut irradiation is another phase of interest here which has not yet been considered in the Handbook. Much remains to be done in the establishment of realistic limits in many practical hazard situations. Simple tabulations, as in the handbooks, are not appropriate. The whole problem of sound management of radiation control will be magnified if such limits are accepted in definitive legislation, without allowances for actual exposure circumstances.

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