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Progress Report

HEALTH PHYSICS DIVISION

QUARTERLY PROGRESS REPORT

FOR PERIOD ENDING JANUARY 15, 1950

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
CARBIDE AND CARBON CHEMICALS DIVISION
UNION CARBIDE AND CARBON CORPORATION
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HEALTH PHYSICS DIVISION

K. Z. Morgan, Director 12/14/53 for N. T. Brown SUPERVISOR CENTRAL FILES ORNL
F. Western, Assistant Director

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[redacted]

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TABLE OF CONTENTS

INSTRUMENT DEVELOPMENT	5
Fast Neutron Instrumentation	5
Continuous Water Monitoring Instrumentation	5
Low Level Alpha Scintillation Counter	6
WASTE DISPOSAL STUDIES	7
Water and Sewage Treatment Process	7
Survey Studies of White Oak Lake and Clinch River	8
Instrumentation	8
Miscellaneous Activities	9
THEORETICAL PHYSICS	10
Projects Completed	10
Active Projects	10
EXPERIMENTAL PHYSICS	11
SPECIAL PROBLEMS GROUP	12
Surface Dose of Uranium and Thorium	12
Backscattering	12
Absorption of Beta Radiation	13
Fast Neutron Monitoring with Commercial Films	13
Neutron Monitoring by NTA Films	14
Neutron Monitoring with Palladium	14
URINALYSIS	15
PERMISSIBLE INTERNAL DOSE	17
EDUCATION AND TRAINING	17

This report covers the activities of those groups in the Health Physics Division primarily engaged in Applied Research or Development. More or less routine activities of the Survey-Monitoring Section are covered in the Laboratory Weekly Progress Report.

INSTRUMENT DEVELOPMENT

Fast Neutron Instrumentation. **A.** The portable battery operated fast neutron survey meter, described by G. S. Hurst in report ORNL 485, has proven to be reliable and a desirable instrument in the past six months of usage in the pile building. The Health Physics Survey-Monitoring Section is procuring three instruments to increase its fast neutron surveying capacity. Large numbers of this instrument will not be built as it is regarded as an interim model (see following paragraph).

B. G. S. Hurst has completed in rough draft a report in which the critical specifications of a special type of fast neutron dosimeter are calculated. This instrument would be designed for measurements in unidirectional beams, and would be unique in that a good approximation to the dosage (or energy lost in tissue) would be given by considering count rate only. A result is the simplification of associated electronics such as to require only a one or two tube amplifier. The report is now being criticized and is to be issued shortly. Components and apparatus are being procured and arrangements are being made to experimentally test this design with monoenergetic neutron beams.

C. An a-c operated, portable, fast neutron monitor with alarm has been constructed and tested. A report is now being written by R. J. Farber, and drawings are to be made. The Survey-Monitoring Section is expected to have three models constructed.

D. A fast neutron meter, integrating version considering both flux density and pulse heights, has been constructed (and is now being "debugged") by F. M. Glass of the Radiation Detection Section of the Instrument Department. This activity is in the interests of the Technical Division Shielding Program as well as the Health Physics Division.

E. The proportional counter development is continuing with application to all of the above instruments.

F. Film calibration for fast neutrons related to personnel monitoring was thought to have need of a special design of the instrument noted in paragraph **A** above. Work was started, then stopped due to pressure of other problems, and the job is now inactive.

Continuous Water Monitoring Instrumentation. This work, mentioned in the preceding quarterly report, is presently inactive. Work may be started in about one month.

Low Level Alpha Scintillation Counter. One laboratory model is being made for testing by the Health Physics Counting Room and the Chemistry Section.

WASTE DISPOSAL STUDIES

During this period there has been no change in the permanent research staff of the Section nor in the personnel assigned from other agencies and groups as mentioned in previous quarterly reports.

Water and Sewage Treatment Process. A major part of the program is continued study of the well-known and widely used methods of water, sewage, and industrial waste treatment. The general purpose is to determine the efficacy of such sanitary plants and processes in the removal of various radioactive materials from water or waste liquids, and to evaluate and adapt these methods as a means for economical treatment of relatively large volumes of slightly or moderately contaminated radioactive wastes.

The small model water treatment plant had to be removed from Building 813 which was torn down beginning October 17. Duplicate stainless steel units have been completed and the two plants set up ready to resume operation in a laboratory of the Health Physics building. Laboratory work has been continued on the removal of P^{32} and also I^{131} by modified water treatment methods and a report on the P^{32} work has been compiled for limited distribution. It was found that the removal of P^{32} by these processes is very efficient, but the removal of I^{131} by the methods tried thus far is relatively poor. It is planned to continue both laboratory and semi-works experiments on a number of other radioisotopes and to try various modifications of treatment before decontamination of mixed wastes is studied.

Studies of sewage treatment processes have included operation of sewage sludge digestion flasks for extended periods with daily additions of raw sludge, analyses of the sewage, and collection and analysis of the gas evolved. The purpose is to determine the digestion and other characteristics of the local sewage as a preliminary to experiments on the absorption and removal of various radioisotopes by sewage constituents. Also a six-foot sewage filter column has been dosed with a dilution of I^{131} in sewage at filtration rates from 5.6 to 18.3 million gallons per acre daily. Preliminary findings indicate a reduction in activity ranging from 40 to 24 per cent in this range of dosage.

Two small series of experiments on the extrusion of radioisotopes from water during freezing have been completed and a memorandum suggesting the course and value of further work on these phenomena has been prepared.

Apparently progress has been made and tentative approval has been given toward the provision of more adequate facilities for waste disposal research which was proposed several months ago. These would include a building for laboratories and for semi-works and pilot plant space to be devoted to water and waste decontamination and related study projects which are of particular interest to a number of agencies.

Survey Studies of White Oak Lake and Clinch River. Much of the work on survey studies has been in cooperation with the TVA ecological reconnaissance and the comprehensive biological study project which is authorized and scheduled to become active early in 1950. This has included the study and improvement of techniques for the assay of biological specimens and mud, and for mud and water surveys in order to measure more accurately the exposure and radioisotope concentration levels of the biological organisms to be studied. A large wood stave tank previously made available for instrument testing was prepared for the storage of uncontaminated fish to be collected and used by TVA personnel in connection with this project. A special study has been made in an effort to evaluate the magnitude of common errors in beta counting of biological and other bulky materials and to indicate correction factors for errors due to variations in the spread of samples, scattering from sides of counting dishes, self absorption losses, and other factors.

Hydraulic and hydrologic data concerning variations of flow and time of water and wave travel in Clinch River in relation to discharges from White Oak Creek have been analyzed and the first in a series of reports on these studies has been issued as ORNL 562.

Some work has been done in cooperation with the AEC geological study project in its program of core drilling in and around the Laboratory area for the exploration of ground water movement and evidences of contamination.

Instrumentation. Further work on the development and calibration of probe instruments for mud and stream water surveys has been done. For continuous measurements of radioactivity and water discharges at White Oak Dam a pilot model gamma ray monitor has been operated more or less continuously at the dam for testing and calibration. A project has been approved for installation of continuous monitoring, water level recording, and telemetering at White Oak Dam in order to provide information for the special survey studies and also routine operating data.

Instruments have been adapted for continuous indication and recording of levels of radioactivity in different parts of the continous waste treatment

experimental units in connection with water and sewage decontamination studies.

Miscellaneous Activities. Three papers were prepared and presented by members of the staff at meetings during this period: O. R. Placak on "Investigations on Radioactive Waste Disposal in Relation to Water and Sewage Treatment" at the Twenty-first Annual Meeting of the Kentucky-Tennessee Section of the A.W.W.A. and the Third Annual Meeting of the Kentucky-Tennessee I. W. & S. W. A., Lexington, Kentucky, October 31 and November 1, 1949; R. J. Morton on "Public Health Aspects of Atomic Energy" at the General Session of Thirteenth Annual Meeting, Mississippi Public Health Association, Jackson, Mississippi, December 13, 1949; and C. P. Straub on "The Sanitary Engineering Aspects of Radioactive Waste Disposal" at the 116th Meeting of the American Association for the Advancement of Science, New York, New York, December 26 to 31, 1949.

O. R. Placak has served and done considerable work on the Subcommittee on Waste Disposal, National Committee on Radiation Protection. This has included attendance at a Subcommittee meeting, completion of a draft of recommendations for exhaust air criteria applicable to laboratory hoods, and review and comment upon several drafts on other subjects by Subcommittee members.

Detailed activities of the Waste Disposal Research Section are covered by monthly reports prepared for limited distribution by R. J. Morton.

THEORETICAL PHYSICS

Projects Completed. The calculation of collision density for a beam of thermal neutrons on a tissue slab was completed, and a paper giving the solution and some discussion of its significance in determining maximum permissible exposures is to appear in the February issue of *Nucleonics*.

The gamma ray mass absorption coefficient project completed jointly by W. S. Snyder and J. L. Powell was issued jointly by the Health Physics Division and the Summer Shielding Session. This report is now in process of declassification and is to be issued as ORNL 421.

A paper, "An Alignment Chart for Monte Carlo Solution of the Transport Problem," jointly authored by Snyder, Goertzel and Spinrad, was prepared for publication in a forthcoming volume of the Procedings of the Conference on Monte Carlo Methods at Los Angeles.

Active Projects. The thermal neutron problem, mentioned above for the case of an incident normal beam, is being considered for the case of a general distribution of the angle of incidence of the neutrons.

A method has been outlined for determining energy losses of charged particles of intermediate energies; *i. e.*, which do not carry bound electrons and have velocities lower than the K shell velocity of the stopping atom. The results obtained are also of interest in evaluating energy losses for low energies.

EXPERIMENTAL PHYSICS

The project to study the distribution or reactor stack gases, discussed in the two preceding quarterly reports,[1] is in the midst of instrument construction and is about two thirds completed. The usual "de-bugging" of apparatus consumes most of the time of two people in the section.

A trip was taken to the Los Alamos Laboratory to obtain data on particulate fall out from atmospheric contamination. The data will be useful in evaluation hazards due to radioiodine or other volatile isotopes. Some data have been received and more recent data will arrive shortly.

Two members of the section were on loan to the Geological Survey during the month of November. A test flight of the instruments aboard the survey aircraft for uranium prospecting purposes indicated that connection of the conductivity apparatus to the ventilating system was not feasible and it is intended to mount the conductivity tube on the outside of the aircraft. A test of the mounting and operation of the instrument is planned in February.

(1a) Morgan, K. A. and Western, F., *Health Physics Division Quarterly Progress Report for Period Ending July 15, 1949*, ORNL 375 (August 23, 1949).

(1b) Morgan, K. Z. and Western, F., *Health Physics Division Quarterly Progress Report for Period Ending October 15, 1949*, ORNL 495 (November 29, 1949).

SPECIAL PROBLEMS GROUP

Surface Dose of Uranium and Thorium. The beta surface dose of uranium was measured with an extrapolation chamber. The gamma radiation is included in this experiment. The result was 239.86 mrep/hour, corrected for 760 mm Hg and 0°C. The determination of the total dose for uranium and thorium is in progress and will probably be finished in the near future. A considerable part of the time was spent in calibration and readjustment of the extrapolation chamber.

Backscattering. Backscattering experiments were conducted with several sources such as P^{32}, S^{35}, and Sr^{90}. The backscattering was measured with an extrapolation chamber, and the experiments will be repeated with a beta proportional counter. The backscattering was measured in percents of the ionization produced by the source only. The source was deposited on rubber hydrochloride having negligible backscattering itself. Eleven elements were tested, ranging from Be to uranium. The backscattering material was placed directly behind the rubber hydrochloride. The effective thickness of the scatterer was practically infinite (multiple backscattering). The distance between the rubber hydrochloride and the chamber was variable from 1 to 25 mm. The detailed description of the measurement will follow in a later report.

The primary radiation of each source has a wide spectral range from very low values to a maximum energy about 1.72 Mev for P^{32} and 0.168 Mev for S^{35}. Since exact experiments would require a defined single energy, the observations cannot yet be evaluated with certainty. The following preliminary results were obtained:

1. The amount of backscattering increases with increasing atom number Z, rapidly for lower Z and medium Z, and to a lesser degree for high Z.

2. The relative intensity of backscattering is higher from a high energy source (P^{32}) than that from one of low energy (S^{35}).

3. Interposing absorbers between source and chamber (air distance or preferably Al) reduced the backscattering from lower atom numbers by a much larger percentage than that from high atom numbers. For instance, 6.6 mg/cm^2 Al as an absorber reduced the backscattering from Be by 45% and that from Pb by 8.6%.

The result was considered as a possible indication that the backscattered electrons from Be have a lower average energy than those of Pb. These experi-

ments had to be discontinued temporarily.

Absorption of Beta Radiation. Absorption experiments of beta rays with several materials are in progress.

Fast Neutron Monitoring with Commerical Films. The films were investigated for blackening rather than for tracks. A Po-Be source was used for exposures from one week to more than 35 weeks tolerance (2.5×10^7 to 1×10^9 N_f/cm^2). One part of the film was exposed to the direct radiation (open window), while the other part was shielded by 0.07 in. lead. While relatively "fast films" failed to show a linear relation between flux and log of blackening with a densitometer, the relationship for slow films (Ansco process film) could be graphed as a straight line on log paper.

The shielded portion of the film showed an increased blackening over the open window portion. This suggested that secondary X-ray or beta radiation is produced in the lead either by the primary neutrons or by some gamma radiation or by both. A number of investigations have been conducted to decide the origin or nature of the blackening, as follows:

1. The distance of the source excluded heavy particles such as alpha and primary protons.

2. Since aluminum between the source and lead shield did not reduce the blackening, primary beta rays are excluded.

3. As to the question of primary gamma radiation, one cobalt and one radium source showed less blackening behind the lead shield than behind the open window, *i. e.*, the opposite behaviour of Po-Be. Apparently the lead reduces the blackening from the gamma radiation of cobalt and radium but not the radiation from Po-Be.

4. Additional aluminum shielding between the lead shield and the film, using Po-Be, eliminated or reduced this blackening. It is, therefore, possible that this type of radiation consists either of very soft X-rays, beta radiation, or both probably produced by the primary neutrons of Po-Be by inelastic scattering lead.

5. By exposing the film to the Po-Be source in such a way that the film is parallel to the direction of the neutron beam (striking incidence) actual recoil proton tracks could be observed.

The final evaluation of these results, however, will require more investigation.

Neutron Monitoring by NTA Films. The supplementary report on neutron monitoring by means of NTA emulsion was finished, and is in the process of publication as ORNL 547 (unclassified).

The track expectancy in NTA emulsion previously reported in MDDC-890 was recalculated on the basis of Eastman's analysis of composition of their present NTA emulsion, and B. E. Watt's determination of the fission energy spectrum (LA-718). The new values were somewhat higher than those reported previously.

Track densities found were greater than those expected from the emulsion alone, and it was determined that this was the effect of the protons formed in the film wrappers. The excess, with fission neutrons was on the order of 25%, and with Po-Be neutrons on the order of 200%, *i. e.*, the number of externally formed protons which were being recorded was a function of incident neutron energy.

The fading of the latent images of proton tracks was investigated. The rate of loss was found to vary with different batches of film, but could be diminished by using a longer development time. With the one week cycle of film change now used, probable track loss is approximately 12% in most of the batches tested. It was also noted that when the emulsion was mounted on glass plates, the latent images tended to greater stability.

Calibration and monitoring procedures were reviewed as to statistical reliability. It was found that with the more sensitive batches of film, and using the current tolerance values (*K.Z.M. Jour. Ind. Hyg. & Tox.*, September 1948) exposure in the range of tolerance doses could only be determined to within a factor of two.

A more sensitive and reliable method of monitoring personnel for neutron exposure is still being sought.

Neutron Monitoring with Palladium. Investigation was begun on the possible use of palladium as a fast neutron detector. This was suggested by resistance changes noted by B. R. Gossick, working in the Physics Division, when irradiating Pd coils with fast neutrons. If this effect can be determined to be due to fast neutrons, it may be used for monitoring.

URINALYSIS

The exploratory survey for determining beta-gamma activity in urine specimens of Laboratory employees handling large quantities of beta-gamma emitting materials has been continued during the period. Urinalyses for alkaline earth and rare earth beta-gamma emitting elements have been made on 38 individuals.

A tabulation of the results of the activity found in the samples is listed below. The beta-gamma activity was determined by counting the sample in a G-M counter with a thin mica window. The geometry was 27.5%.

Net cts/min excreted per day	Number of individuals
<5.0 c/m	15
5.0 to 10 c/m	9
10.0 to 20 c/m	5
20.0 to 50 c/m	2
>50.0 c/m	7

Detailed studies of the nine cases which showed excretion >20 c/m per day have been made. Seven of the nine samples showed a decay with a half-life of approximately 60 days. This beta activity is believed to be strontium^{89}. Absorption curve studies substantiate this fact. The activity of the samples from the other two individuals was shown to be strontium^{90}—yttrium^{90}. This was proven both by absorption curve studies and by radiochemical separation with a subsequent study of the decay and/or growth of the component parts.

Of particular interest was the case which showed the highest activity. This case was studied in detail by the analysis of weekend samples for seven consecutive weeks. The following table shows the total beta-gamma activity found during the period checked:

	Cts/min excreted per day*
1st week	830
2nd week	214
3rd week	201
4th week	82
5th week	59
6th week	56
7th week	54

*Activity due to Sr^{90}—Y^{90} in equilibrium.

This employee was temporarily taken from laboratory work after finding the high level of activity which was being excreted the first week. A rapid drop in the excretion level is observed on succeding weeks.

A further study was made in this one case to determine if the Sr^{90} - Y^{90} was excreted in equilibrium or whether the excreted activity was Sr^{90}. A urine sample was assayed and the beta-gamma activity determined 15 hours after excretion. The sample was counted frequently over a period of five days. Extrapolating the growth curve to zero time, the activity increased from 10.3 c/m to 22.6 c/m in 5 days. Assuming that a Sr^{90} - Y^{90} equilibrium exists in the body, this would indicate that the Sr^{90} is excreted preferentially.

PERMISSIBLE INTERNAL DOSE

Calculations for permissible concentrations for some 27 radioisotopes completed during this quarter are recapitulated in Report No. ORNL 591.

EDUCATION AND TRAINING

The Education and Training in Health Physics during this period included programs for the following groups and persons:

1. The eleven NRC Fellows who began their training here on October 5, 1949, have during this quarter been occupied with the following courses:

Atomic Physics	4 hrs. per week
Electronics and Instrumentation	4 hrs. of lecture per week and 3 hrs. of laboratory per week.

Two of the Fellows, who have had considerable work in electronics were excused from participation in that course to do lab work with Health Physics Research groups. One has been assigned to the Experimental Physics group and the other to the Special Problems group.

2. An employee of the U. S. Department of Agriculture, Agricultural Research Administration, Beltsville, Maryland, spent two weeks at the Laboratory with the various Health Physics survey groups on a schedule worked out jointly by this section and the survey monitoring section.

In addition to the above training program, the section has been working in two major problems: (1) The organization and credit for the AEC Technical Fellowship program for next year, 1950-51, and (2) the writing of a manual and the preparation of a curriculum for the Civil Defense program.