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EG&G/DBM QUARTERLY REPORT

JULY - OCTOBER 1971

Approved by:

A handwritten signature in dark ink, appearing to read "H. A. Lamonds", written over a horizontal line.

H. A. Lamonds
DBM Program Executive

This report is unclassified:

A handwritten signature in dark ink, appearing to read "R. Lynn", written over a horizontal line.
(Classifying Official)

Work performed for the Division of Biology and Medicine of
the Atomic Energy Commission.

MASTER

SANTA BARBARA DIVISION
EG&G, INC., 130 ROBIN HILL RD., GOLETA, CALIF. 93017

Handwritten initials, possibly "ds", in dark ink.
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1. TECHNICAL PROGRESS (SANTA BARBARA DIVISION)

ECOLOGY STUDIES AT NTS

Analysis of conventional radiation dose-rate instrument readings made eight months after Schooner detonation shows that these instruments will give some indication of redistribution of material around that crater area. In July 1969, beta dose rate readings were obtained in plots which had been covered with 6-mil-thick polyethylene sheets 6 meters square from Time-Zero until 12 days post detonation, at which time the sheets were removed. These sheets prevented contamination of the covered area by fallout during that period. A comparison of the dose rate readings for covered areas compared to non-covered suggests that as much as 10% of the total radioactivity present in the center of the fallout pattern at eight months post event may have arrived there after D + 12 days. The late-arriving material would of course be the result of the redistribution of initially deposited debris as well as added material blown from the crater about one mile away.

Dried plant material from annual species in the Project Baneberry fallout pattern has been weighed. Analysis of the data has not, however, been completed. The dosimeters used to investigate total doses at Baneberry have been returned to the laboratory at Santa Barbara for reading. This work is nearly complete.

Plant communities in the Pu-contaminated NTS areas have been identified using as a basis for the ground investigation the aerial photographs made by the ARMS Group of the Las Vegas Division.

PASSIVE NEUTRON DETECTION TECHNIQUES

This task is concerned with development of a low-level neutron detection system based on fission-track detector methods and incorporating a spark counter developed with DBM funds during FY71. Work during the first quarter of FY72 included design of a preamplifier for the spark characterization studies.

Spark Counter Preamplifier

Previous work with the spark counter had shown that proper matching of the counter output was necessary if high-frequency ringing (>120 MHz) and consequent multiple counting was to be avoided. A preamplifier was built, following an original ORNL design, that made the counter one leg of a PI network filter and the preamplifier input the other. Subsequent modifications to this original concept resulted in a workable solution that allowed selection of the energy storage capacitor. This permitted alteration of the amount of aluminum vaporized from the Mylar film at each count, thus allowing control of spot size. This directly affected the upper limit of the system. The final preamplifier design which has two transistors, and a fixed input filter network, has proved satisfactory during several months of operation.

Fabrication Techniques

The 0.5-mil-thick Kimfol used as the fission fragment catcher foil was studied to determine the cause of the undesirable scatter in the data observed during initial operation of the spark counter in FY71. The salient feature discovered here was that stresses placed on the Kimfol film during exposure and particularly during etching caused anomalous holes to be formed. These holes had, of course, been counted as real fission fragment holes, resulting in the anomalous data. To correct this, improvements were made in the method of holding the Kimfol during exposure as well as during etching in the 60° C KOH solution. Stress-free conditions of punching, exposure, and etching have resulted in good data.

Etching Parameters

Etch time parameters were studied in conjunction with spark counter voltages. Microscopic examination of the aluminized Mylar sheets used in the spark counter, along with the Kimfol foil containing the holes, revealed that not all holes produced tracks at low voltages, and at high voltages the aluminizing

was evaporated over such a wide area that several counts were suspected of originating in one hole. This dilemma was solved by use of high-voltage sparking to pierce all holes and incipient holes followed by counting at a lower voltage to quantify the number of holes. This technique works very well. The high-voltage sparking coupled with low-voltage data collection was used to establish the etch time curve shown in Fig. 1. A plateau region is seen to begin at about 75 minutes and extend to at least 120 minutes. An etch time of 90 minutes was selected as standard.

Fig. 1. Etch time parameters.

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Reproducibility of Radiators

A series of runs was performed to test reproducibility. Four measurements at the 1×10^9 n/cm² level yielded a standard deviation of 2.8%. Twelve measurements with six different radiators at 1×10^8 n/cm² yielded a standard

deviation of 6.5%. Since no special care was used in obtaining these data, they are probably representative of routine work. Better precision may be obtained from larger foils, since the number of counts is directly related to the foil area. The active area of the present foils is 5/8 inch in diameter. Some improvement can also be obtained by making the uranium deposit thicker. Present foils are one micron thick. Measurements have shown that this is about 40% as efficient as an infinitely thick layer.

System Sensitivity

The calibration constant, or sensitivity, of the ^{238}U foils used thus far is approximately 2.7×10^{-6} counts/neutron-barn, which is 2.8×10^{-6} counts/n/cm² at 0.55 barns for σ_f and 1.886 cm² for the active area. Ten counts would imply $\sim 3 \times 10^6$ n/cm² from a fission spectrum. This is approximately 10 mrad-tissue and hence is a rather low dose. Obviously, the foil background must be low for such measurements to mean anything.

The upper limit of this detector system is determined by geometrical considerations of hole overlap in the aluminized Mylar sheet. This is presently under study experimentally. A theoretical prediction shows that $\sim 7 \times 10^9$ n/cm² would be the maximum readable with the two micron radiators. This corresponds to about 20 rads-tissue. Thinner radiators would allow extensions to higher fluences, but at the expense of the lower end.

System Background

Background data have been accumulated for a number of different systems, including ^{235}U , ^{238}U , and ^{232}Th with a Lexan catcher foil, and ^{238}U with a Kimfol catcher foil. The latter data exhibited only 1 count for the 6 detectors used. From this we can calculate that the 10 counts mentioned above are essentially background free, and the resulting fluence (3×10^6 n/cm²) will have a standard deviation of $\pm 30\%$ or less.

Angular Sensitivity

Since these systems are flat coin shaped items, they are not expected to be isotropic in sensitivity. Initial experiments, shown in Fig. 2, reveal that a dip of about 30% occurs when the plane of the radiator is aligned with a radius vector to the source. More data are being taken to better delineate this effect. First blush analysis would imply that little worry need be expended in this direction if the detectors are mounted close to a scattering medium, i. e., in a film badge environment.

Fig. 2 Detector angular response in scatter-free response.

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System Performance in Typical Radiation Environment

Figure 3 shows the detector response in a scatter-free geometry near a very small ^{252}Cf spontaneous fission source. It is seen to follow a $1/R^2$ slope

accurately. These data were taken with six individual radiators from the original batch of ten, and used an average calibration factor derived from measurements of the remaining four radiators. The scatter is low and would be acceptable for most uses.

Figure 4 presents similar data, but in this case the foils were positioned at various distances away from a tissue-equivalent phantom (a thin plastic cylinder filled with water). The source was located 20 cm from the phantom surface and the detectors were located on the surface and 2, 4, 6, 8 and 10 cm from the surface. Data were taken with and without tissue-equivalent fluid in the phantom. It can be seen that backscatter above 1.5 MeV, the natural threshold for ^{238}U , is about 30%. This is what one would expect during typical use of this detector as a neutron dose monitor.

Future Work

Scheduled work will involve reproducibility at low levels (10^6 to 10^8 n/cm²), angular sensitivity at the surface of a phantom and in free space, upper limit determinations and methods to extend the range, and more extensive background data.

HENRE SPECTRUM MODIFIER

The primary objective is the design of multilayered spectrum modifier for a high-current D-T neutron generator to produce a simulated nuclear weapon neutron spectrum. A secondary objective, based on a carry-over from FY71, is to calculate the HENRE near-field neutron spectrum as a function of angle.

The HENRE near-field calculations have been modeled for Monte Carlo analysis using SORS-N. These results will be analyzed during the next report period. The spectrum shifter computations will also be modeled for Monte Carlo (SORS-N) analysis during November 1971.

Fig. 3 System response in air.

3769-A

Fig. 4 System response in pressure of tissue-equivalent phantom.

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EXPOSURE RATE CONVERSION STUDIES

The objective of this task is to perform detailed analytical simulation of selected ground-based radiation source configurations for providing improved air-to-ground correlation procedures for typical ARMS missions.

Technical coordination has been undertaken with ARMS operations personnel at EG&G/LVO to establish priorities of the various phases of this work. Typical mission scenarios are presently being formulated so that the associated calculations can be done in the most effective order. These mission scenarios will be modeled for Monte Carlo² (SORS-G) analysis during the next report period.

DELINEATION OF COSMIC RAY EFFECTS

The objective is to characterize the cosmic ray component of the ARMS background as a function of latitude, flight altitude, and atmospheric conditions.

The cosmic ray dependence on latitude has been thoroughly investigated and reported by Holt, Neher and Anderson, and others. The latitude dependence is, as expected, most pronounced at the top of the atmosphere, where ionization rates vary by as much as a factor of eight between the latitudes of 0 and ~55 degrees. At sea level, the ionization rate variation (0 to 55°) is about a factor of two and at 680 mbars it is about a factor of three. Schopper indicates a larger latitude dependence during periods of minimum solar activity. Beyond about 55° latitudes north or south the cosmic ray intensity remains relatively constant. The latitude dependence is approximately the same for electrons, gammas, μ mesons, and neutrons.

DEVELOPMENT OF ISOTOPE CONTOURING TECHNIQUES

The objective is to develop analytical techniques for determination of radioisotope inventory contours by analysis of aurally (ARMS) measured pulse-height spectra.

Several pulse-height unfolding procedures have been investigated especially with respect to their applicability to ARMS conditions. The typical ARMS pulse-height spectrum consists of many peaks and a large continuum distribution. This continuum is due both to incomplete absorption (Compton) events in the NaI (Tl) detectors and to inscattered radiation from the air and the aircraft structure. The processes will be studied analytically by use of Monte Carlo techniques to assure reliable interpretation of the measured spectra.

INITIAL RADIATION STUDIES

The objectives of this task are to 1) establish weapons effects parameters and standard conditions for development of initial radiation methodology, and 2) characterize the prompt gamma and neutron fields for selected weapon parameters and initial conditions.

Preliminary plans have been outlined to accomplish this task. The findings of the NAS/NRC Initial Radiation Group will be utilized as a primary guide in this work.

DETECTOR ARRAY RESPONSE CALCULATIONS

The objective is to characterize the energy and angular-dependent response of the ARMS detector array by use of Monte Carlo transport techniques.

The angular distribution routine in SORS-G has been successfully modified and tested. This feature of the Monte Carlo analysis is necessary to compute the angular dependence of the ARMS NaI (Tl) detector array response. The detector array will be modeled for analysis during the next report period. The effects of inter-detector and array package perturbations will be included in this model.

ARMS DATA ANALYSIS COMPENDIUM

The objective is to assemble and evaluate all pertinent technical information generated to date which is related to the analysis and interpretation of ARMS data.

Preliminary discussions have been held between Santa Barbara and Las Vegas personnel to establish the content and format of the compendium. The major efforts in this task are planned for the third and fourth quarters of FY72, so that most of the FY72 progress can be included.

2. TECHNICAL PROGRESS (LAS VEGAS DIVISION)

RADIATION PROPAGATION AND FREE FIELD EXPERIMENTS

Analysis of the results from the air-ground buildup experiment at Yucca Lake (CEX -63.8) has been completed. The effort included a thorough error analysis. A portion of the theoretical calculations are being rerun in Santa Barbara. Preparation of a CEX report to combine the theoretical and experimental results has begun.

A meeting of the Shielding Subcommittee of the National Academy of Sciences was attended this quarter. Primary discussion was on initial radiation. The working group report was finalized.

HENRE

Feasibility study for a new accelerator has been drafted. Meetings were held with Fred Haywood to formulate a plan and schedule for further target research. Three areas of research were outlined: 1) further D-T studies at the DOSAR, 2) heat dissipation and gas flow studies at Y-12 and 3) D-T studies using higher beam densities. A suitable machine and location for the third area of research has not yet been designated.

A detailed thermal analysis of the existing self-replenishing tritium target revealed large temperature drops in the Ag-Pd layer and in the layer comprising the copper posts. A different design, maximizing heat dissipation, will be required for high yields and small targets.

A new elevator control and communication system has been ordered by REEC Co from Marshall Elevator Co. When it arrives, EG&G will install and test the system.

BIO-MED STUDIES SUPPORT

Time-lapse photography was continued from the station at the NTS in support of ecology studies at Santa Barbara. Physical movement of the station by one of the weapons tests has caused a slightly different view to be photographed. Adjustments required to obtain original view are being evaluated.

A quarterly inspection of the Rock Valley Irradiation Facility was made.

IR SCANNER INTERPRETATION TECHNIQUES

Maury Veech and Lynn Godfrey of the Hanford Laboratory examined the IR scanner data obtained in May and June. Weather conditions and mechanical problems with the thermal mapper had compromised the data. Dr. William Fiero of UNLV assisted in scanner data interpretation.

A scanner checkout mission was made on 7 July to study the performance of the system with the In-Sb and Hg-Cd-Te detectors. A broad spectrum of settings were used over variable terrain to determine optimum values of DC level, signal gain, etc. The experiment produced a much better understanding of the system. Hopefully, better quality data can be anticipated in the future.

Dr. Paul Tueller of the Renewable Resources Center (University of Nevada at Reno) visited our facilities on 30 July to discuss the technical requirements for scanner surveillance of the Hot Creek Valley. Nine other sites under study by the Center were also proposed. A preliminary mission description was sent to Jared Davis for NVOO approval.

ARMS SUPPORT

Meetings were held with Austin O'Dell of SBD to coordinate theoretical and experimental efforts of air-to-ground radiation correlations. Soil samples from the Jean-to-Nipton range were obtained to determine isotope concentrations. Samples of at least 500 grams are necessary for good statistics. The 4 x 4 crystal counting efficiency was computed for thick self-attenuating

soil samples of various thicknesses. This will aid the program to estimate isotope concentration in the soil from ARMS data.

Cosmic ray contribution to ARMS and exposure rate conversions were reviewed and updated. Several informal discussions were held concerning the value of routinely surveying for background radiation at 500 ft instead of 300 ft. Because of many operational and technical advantages a flight altitude of 500 ft was chosen for future routine surveys.

An informal discussion was held with Dr. Robley D. Evans (MIT). The History and rationale of the man-rad concept and basic information on the behavior of radon and its daughters were discussed.

Discussions were held with Health and Safety Laboratory personnel on many aspects of background radiation. A tie-in of background radiation and population would be very valuable, but caution should be taken on interpretation. Cesium levels from world wide fallout approaching 1 μ Ci per hour are common. Health and Safety personnel easily discern this component in most of their measurements.

They suggested that the deviations in our gross counts vs altitude (or pressure) during spirals is probably due to radon rather than cosmic ray changes. They expect cosmic ray contributions vs air pressure to change very little from year to year and only 10 to 15 percent between Maine and Florida. A tie-in of our proposed plume delineation for Brookhaven and dose rate measurement at the ground would be very desirable. They could participate.

Spectral data taken from certain areas during ARMS surveys showed evidence of some components which could not be identified. It was then necessary to unfold these data to provide a more positive identification of these unknowns. The results were quite useful.

Because of the large size of the spectral unfolding response matrix (170x170) and its expected increase (220x220), attempts are being made to do unfolds in parts. This will provide a routine for use on a small computer-analyzer.

Results to date are encouraging. Extra time is required to do unfolds in parts. A report is being written to include all of the experimental work done, the response matrix development, and the use of the matrix to execute an unfold.

A soil moisture experiment was conducted in which a single 4x4 NaI detector was used at ground level. Measurements were made before and after the ground was heavily watered. Initial results indicate that the ^{40}K peak decreased about 23% for a 30% increase in soil moisture while the net count decreased 10%.

Contributions of radon and its daughters in the atmosphere to the ARMS detector system remain uncertain. The literature concerning radon is both extensive and intensive. Some experimental data have been obtained. Vertical gamma gross count, gamma spectra, and filter beta and gamma counts have been obtained over Lake Mead and the Pacific Ocean where radon daughters were observed.

Radon and daughters (not in equilibrium) are found both in the atmosphere and in the ground, and are nonuniformly distributed. Radon tends to accumulate in a temperature inversion layer. Radon concentration in the atmosphere is generally about 10^{-13} Ci per liter or more. This amount would provide a hundred β or γ counts per second on a ten-minute filter collection from the ARMS aircraft. However, one would need a 100 liter detector to obtain one count per second from the air itself. The fourteen 4 x 4 crystals yield several hundred counts per second at this concentration. These crystals may "see" the radon when the filter doesn't because of stratification of the radon. The significant atmospheric contributors to both the 4 x 4 crystals and the filters are ^{214}Pb and ^{214}Bi , both of which are β & γ emitters (no α).

Evaluation of spiral data indicates that the filter will register ~ 1000 β counts per minute after a 10-minute air collection for each 400 counts / sec perturbation in the gross count. The assumption here is that β and gamma emitters effecting the crystal package are the same isotope.

A NaI β counting system has been assembled and sent along with the ARMS truck which is on survey. The plan now is to collect one filter at the end of each flight (if possible) for readout (β count) in the truck. These data will be used to correct gross count data on an experimental basis.

The prognosis for success in using filters and β count to define the effect of radon daughters on the crystal gamma count is good but not assured. The accumulation of more filter samples will certainly help solve the problem.

PERTINENT PROJECTS RELATIVE TO DBM PROGRAMS

HAVE SINEW Tests

During the period 16-28 August 1971 the ARMS aircraft and personnel participated in Project HAVE SINEW at White Sands Missile Range, New Mexico. This project involved the firing of an Athena rocket carrying six separate payloads, which fell on the White Sands Range. Each payload contained ^{182}Ta gamma sources, totaling 100 mCi per payload, as aids to recovery. The ARMS objective was to locate the sources from the air and to direct recovery helicopters and ground vehicles to the impact sites.

The rocket firing occurred on the morning of 20 August, and the aerial search commenced immediately. The search area was determined from preshot calculations of the impact points, modified by data from WSMR tracking radars. The first signals from the sources were detected by the aircraft three hours after the firing.

By 23 August, four of the six payloads had been recovered and found to be intact as expected. In addition, two 50-mCi sources not attached to a payload had been recovered. The two missing payloads had each carried two 50-mCi sources, and all four of these sources were identical. Thus, at least one of the payloads had broken up in flight, and there still remained two 50-mCi sources unlocated, which might or might not be attached to a payload.

The remaining time was spent in an unsuccessful search for two missing sources. By the time operations ceased, an area approximately 10 by 4 miles had been searched. In the opinion of project leaders, the payload(s) to which the missing sources were attached may also have broken up in flight, causing the sources to fall uprange of the search area.

NOAA Snow Depth Evaluations

Additional analysis of snow data (mile-by-mile averages) have been performed. A visit was made with Dr. Peck and Joe Deal to outline efforts for this year. They are:

First Priority: Investigate the dual detector concept to handle the radon problem. The Russians report this as a satisfactory means of delineating airborne contributions. One detector system is collimated downward, preferentially looking at ground radiation.

Second Priority: Gather background radiation levels near or between ARMS survey sites. This information could provide base-line data for later surveys for water equivalent.

Third Priority: Finalize our curve of net count versus water or air depth. Resolve differences with Russian data. Gather some information on isotope distribution versus soil depth.

SANDS and Low-Energy R&D

A Navy Sikorsky helicopter from Imperial Beach has been used for survey work and collection of spectral data in the area around Las Vegas.

Most of these measurements were aimed at determining the best method of cancelling the effect of altitude changes and changes in "background" radiation levels.

Measurements were made in several different areas of varying activities and at altitudes between 50 feet and 150 feet to determine changes in the spectral region on either side of the 60 keV ²⁴¹Am photopeak. The Las Vegas

altitude and summer temperatures curtailed hovering operations and complicated the separation of altitude and isotope effects. Indications are that the spectral shape from 50 to 90 keV is not sensitive to altitude or the presence of hills in the survey area. However, the shape is believed to depend on the presence of "background" isotopes encountered at the NTS and possibly on changes in the amounts of naturally occurring isotopes.

The method of background subtraction used thus far has been based on comparison between counts in the 60-keV photopeak window and those in a second window centered around 80 keV. More accurate methods can be devised and are now being examined. Unfortunately, most these methods sacrifice sensitivity. However, a sacrifice of 30% sensitivity may be justified in view of the deviation (for outside of counting statistics) that have been observed on previous surveys over areas where Pu is not believed to be present.

ARMS Operational Summary

During the first quarter of FY72 the ARMS aircraft made routine radiation surveys of the following electrical utilities (nuclear generating plants):

<u>Facility</u>	<u>Nearest City</u>
Kewaunee Nuclear Power Plant	Carlton, Wisconsin
Pilgrim Station	Plymouth, Massachusetts
Prairie Island Nuclear Generating Plant (Unit 1)	Red Wing, Minnesota
Maine Yankee Atomic Power Plant	Wiscasset, Maine
Yankee Nuclear Power Station	Rowe, Massachusetts

Two large-area survey missions were also flown over the Nuclear Fuel Services facility near Buffalo, New York and over the Savannah River Laboratory, Aiken, South Carolina.

Three special missions were flown in direct support of other government programs:

<u>Program</u>	<u>Location</u>	<u>Objective</u>
APOLLO 15	Cape Kennedy	Possible SNAP recovery
HAVE SINEW	White Sands Missile Range, NM	Point source location
ATHENA	Las Vegas	Point source calibration run

BREN Tower Support

EG&G supported Stanford Research Institute (SRI) in a laser study at BREN Tower. He-Ne laser signals (15 mW) were sent from the Tower to a remote receiver, and vice versa. Transmission at distances up to 10 km was studied to determine scintillation effects. The ultimate goal of the program is to establish safety standards for direct viewing of laser beams by the unaided human eye. SRI obtained all the data required for the present phase of their program.

PERTINENT REPORTS, PAPERS, AND PRESENTATIONS

Reports

Two reports were published in final form:

1. "Environmental Radiation Surveys and Snow Mass Predictions From Aircraft" by L.J. Deal, J.F. Doyle, Z.G. Burson, A.E. Fritzsche.
2. "Gamma Ray Scattering At The Air Ground Interface Experimental" by R. L. Summers. In addition, 19 ARMS survey reports were initially reviewed by AEC Regulatory, and another 6 were in various stages of internal processing during the quarter.

Presentations, Papers, and Articles

P. K. Boyns made a presentation at the Health Physics Society meeting in New York during mid July on the Lost Athena Rocket Recovery. A paper on the same subject has been accepted for publication in the "Health Physics Journal".

Articles were published in the "EG&G Ink" and "EG&G Monitor" describing the ARMS system with emphasis on the Snow Depth Measuring Program.

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