726942

Schedule 189a

JUSTIFICATION FOR OPERATING COSTS & EQUIPMENT OBLIGATIONS FOR

Idaho
Field Office or Laboratory

Date

1. Budget Account No.		2. Project Title: Experimental Cloud Dose Study	
3. Method of Reporting: 1. Monthly		4. Person in Charge: C. A. Pelletier	Principal Investigator: P. G. Voilleque'
5. Contractor: ID Health Services Laboratory	Type	6. Working Location: NRTS	7. Task No.: NA
8. Reactor Concept: NA		9. Materials: NA	
10. Contract No.: AT(10-1)-	11. Project term: From: 1-1-69 To: 6-30-71		12. Contractor Project No.

	FY 1968	FY 1969 Orig. Budget	FY 1969 Current Estimate	FY 1970	FY 1971	FY 1972	FY 1973
13. Man Years: Scientific			1	2.5	2.5	1.0	
Other Direct				.5	.5	.5	
Total			1.0	3.0	3.0	1.5	
14. Costs (In Thousands)							
(a) Direct Salaries			10	20	20	10	
(1) Burden							
(b) Materials & Supplies			2	6	6	5	
(c) Support Services			10.5	28	27	15	
(d) Fuel Fabrication .2							
(e) Reactor Fabrication .4							
(f) Irradiations .6			.5	1	1		
(g) Test Reactors - Other .7							
(h) R&D Subcontracts							
(i) Expendable Equipment							
(j) Computer Services			5	10	10	5	
Total Direct Costs			28	65	64	35	
(k) Administrative Expense							
(l) NRTS Expense							
TOTAL COSTS							
(m) Unliquidated Obliga.				86.9	2		
(n) Equipment Obligations							

NOTE: this has been reduced for provenancing

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Subj: Schedule 189A Justification for Operating Costs & Equipment Obligations for Idaho Field Office or Laboratory, Experimental Cloud Dose Study

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Schedule 189a

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Idaho
Field Office or Laboratory

Date

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16. DATES AND [illegible]ERS OF PUBLICATIONS

None on the subject study to date. Those publications which have a bearing on the study are included below.

17. SCOPE

The purpose of the study is to obtain experimental data necessary to improve mathematical models presently being used to calculate radiation doses at ground level from airborne radioactivity released from reactor stacks, containment vessels, etc. The models currently being used are based on theory ~~which impart at least has~~ portions of which have not been verified experimentally. The recent survey carried out by Gammill and Van der Hoven of DRDT ("Survey of Radiological Safety Analysis Computer Programs") pointed out discrepencies as large as 1000 among the models currently being used.

The proposed study is divided into four parts. These are

(a) a parametric study using RSAC (Radiological Safety Analysis Code), ~~[illegible]~~ a computer code developed by PPCo.[1,2] In any theoretical calculation to determine downwind gamma exposures from a cloud of radioactive debris the total exposure is dependent upon such parameters as gamma ray energy, wind speed, horizontal and vertical cloud dimensions and release height. The computer uses these parameters in a complex integration over time and space to calculate an exposure at any given downwind position. It is not certain how sensitive the exposure calculation is to variation each of these parameters ~~is in influencing the total exposure~~. The purpose of the parametric study with ~~the~~ RSAC is to determine ~~how much~~ the variation in dose ~~is~~ caused by variations in these parameters. The study will be accomplished by programming the RSAC code with several combinations of gamma energies, heights of release and hypothetical weather variables and observe the

1. R. L. Coates and N. R. Horton, "Radiological Safety Analysis Computer Program," IDO-17151, May 1966. "RSAC--A"
2. L. C. Richardson "User's Manual for the Fortran Versonian of RSAC, IDO-17261, June 1968.

(b) A study to measure dose ~~building~~ build-up factors in air. All calculations of dose rates from a photon source in air at different distances are normally made using a simple exponential attenuation with a linear absorption coefficient. The calculated dose rates, however, are less than the actual dose rates. The reason for the difference is that the calculation assumes that when a photon is scattered, it is lost from the beam while in reality it can later be scattered back into the beam. The technique used to correct for the error introduced is to multiply the results by a correction factor known as a ~~building~~ build-up factor. The accuracy of the resultant calculations is obviously dependent upon the accuracy of the build-up factor used.

The original source of build-up factors for air was from a calculation of build-up factors for water made by Goldstein and Wilkins[3] using the method of moments. Since the mass and energy absorption coefficients for air and water are approximately the same, it was assumed that the build-up factors for air and water would be the same when the distance from the source is expressed in terms of mean free paths. The study by Goldstein and Wilkins did not go below a source energy of 255 KeV. However, equations fitted to the data [4,5,6] were commonly used to calculate build-up factors for photon sources in the kilovolt range. In some cases the results from the various equations differed by more than five orders of magnitude.

3. H. Goldstein and J. E. Wilkins, Jr., "Calculations of the Penetration of Gamma Rays" NYO-3075, Nuclear Development Associates, Inc. (1954)
4. "Meteorology and Atomic Energy", AECU-3066, p. 101 (1955)
5. David H. Slade, Editor, "Meteorology and Atomic Energy", p. 360 (1968)
6. D. K. Turley, "A Survey of Emperical Functions Used to Fit Gamma-Ray Buildup Factors", ORNL-RSIC-10, (1966)

for horizontal diffusion, evidence indicates that the distribution in the vertical may not be Gaussion. The best way to determine the vertical distribution and its affect on dose is to measure the distribution and dose in the field. This is one purpose for the field tests. Incidently, the measurements of vertical distributions per se will be an important by product of the study, because they will contribute to a better understanding of the vertical diffusion process itself.

The other reason for field testing is to verify the mathematical model derived to predict ground doses.

One hundred field releases are planned over a two year period. NEARLY Monoenergetic gamma emitting radionuclides will be released into atmospheres of different stabilities from varying heights. Ground LEVEL doses will be measured primarily with recording ionization chamber dose rate meters.

(d) Construction of a Mathematical Model. The end product of the study is a mathematical model, based on experimental data, WHICH CAN BE USED TO predict ground LEVEL doses from clouds of gamma emitting radionuclides. Model building will be a continuing effort by all those involved in the study.

Build-up factors for air have also been calculated using Monte Carlo type computer codes. Calculations by Wells[7] were not in complete agreement with the moment method data obtained by Goldstein and Wilkins. Later calculations by Marshall and Wells[8], however, were in good agreement with the moment method data. The discrepancy was apparently caused by the cutoff energy used in Wells' earlier Monte Carlo calculations.

Several build-up factor calculations have been made for monenergetic point sources in the kilovolt energy range. Calculations have been made by Renken[9] using the polynomial method for a 20-keV photon source in sea level air. Also calculations have been carried out to 10 mean free paths for source energies ranging from 12 to 100 keV at an altitude of 75,000 feet by Krumbein, Cohen and Ross[10] using a Monte Carlo code. This calculation is within 5% agreement of that made by Renken for a 20-keV photon source. While the calculations agree with each other, their accuracy for expressing true build-up factors in air is not known. They are however the best calculations available for the kilovolt energy range.

7. M. B. Wells, "A Monte Carlo Calculation of Gamma Ray and Fast Neutron Scattering", Reviews and Lectures No. 110 (Proc. NRDL-OCM Shielding Symposium), Naval Radiological Defense Laboratory (1960)

8. J. D. Marshall and M. B. Wells, "The Effect of Cutoff Energy on Monte Carlo Calculated Gamma-Ray Dose Rates in Air". Transactions of ANS 1966 Winter Meeting, Volume 9. No. 2, pp. 343

9. James H. Renken, "Transmission of X-Rays Through Air", SC-RR-65-141, (1965)

10. A. D. Krumbein, M. O. Cahen, and R. Ross, "Buildup Factors for Point Monoenergetic Low-Energy Photon Sources in Air, "Transactions of ANS 1966 Winter Meeting, Volume 9 No.2, pg. 342.

A report by Bernstein and Weiss[11] states that an initial rough measurement was made of the quality of the gamma radiation from a ^{60}Co source in 1953. They stated that the results suggested agreement with the theoretical calculations of Spencer and Famo[12], however, they did note some indication of the effect of the ground. ~~This information was abandoned in a letter which most likely cannot be obtained~~. Due to sdverse winter weather, Bernstein and Weiss discontinued their studies in air and they made studies in a water medium. Since they obtained excellent agreement between theory and experiment for water, they concluded that the data of Goldstein and Wilkins was reliable for almost any energy and medium. Realizing that the problems involved in making air measurements analogous to the water measurements were rather severe, they decided not to repeat the experiment in air. They did state that they planned to make several specific studies pertaining to the propagation of x-rays in air. Whether they actually made further studies or not has not yet been established.

The disturbing fact is that all of the buildup (build-up) factors for air have been established by theoretical calculations. They have not been experimentally measured. The accuracy of the calculated build-up factors for air is not known. Therefore, the purpose of the study is to measure build-up factors in air and to develop an emperical equation to describe the build-up factors as a function of gamma ray energy and source-detector distance.

C. Field Measurements of Gamma Exposures. Most of the currently used dose models ~~assume~~ Assume that the distribution of the containment (contaminant) within the plume is Gaussian. Although there is ample evidence to support this assumption

11. W. Bernstein and M. M. Weiss, "The Propagation of Gamma-Rays in Air; Progress Report for January 1 - June 30, 1953", BNL-1540.
12. L. R. Spencer and U. Fano, J. Res. NBS 46, 446 (June 1951)

Participation in the study will be roughly as follows:

Study	Participant
Parametric Study	PPCo*
Dose Build-up study	PPCo*, INC**
Field Testing	HSL, INC**, PPCo*, ESSA***
Model Building	HSL, INC**, PPCo*, ESSA***

* Health and Safety Branch under the supervision of Ormand L. Cordes

** Nuclear Technology Branch, Physics Section under the supervision of Russell L. Heath

*** Air Resources Laboratory Field Research Office under the supervision of C. R. Dickson

The contribution of the Health Services Laboratory will be mainly that of the Environmental Branch under Charles A. Pelletier, However, the Dosimetry Branch under Foster Cipperley, the Instrumentation Branch, under Mack Wilhelmsen and the Analytical Chemistry Branch under Claude W. Sill will also contribute to the study.

The division of labor shown above is by no means clear cut. For example, ESSA and HSL will contribute to all parts of the study, ~~and PPCo may take part in the field tests~~. However, the main contributors to each section will be as shown.

We also expect to have the support of the Operational Safety and Technical Support Division of ID because of their direct involvement in safety analysis reviews at the NRTS.

18. RELATIONSHIP TO OTHER PROJECTS

The EXCES program is directly related to the Reactor Safety Program. Its results can be used by AEC personnel, AEC Contractors and AEC Licensees to predict the consequences of Atmospheric releases from nuclear facilities. Having a mathematical model based on measurement will give us more confidence in its predictions, thereby allowing us to evaluate hazards more realistically than before.

The meteorological information acquired from the study will contribute to the field of micrometeorology, a field on which the AEC relies for many reasons other than reactor safety analysis.

Many of the techniques employed by INC to measure incident energy flux have been developed as a result of their support of the LOFT Safety Program.

19. TECHNICAL ACCOMPLISHMENTS THROUGH FY 1969

A field test was carried out on May 3, 1968 in which 31.6 curies of ^{133}Xe were released at a height of two meters into a very stable atmosphere. The stability during the release was categorized as class G. The mean wind speed transporting the ^{133}Xe was measured to be 3.8 m/sec. The vertical and horizontal dimensions of the plume were estimated by photographic methods.

Assuming a gaussian distribution in the plume, EGCA personnel estimated that the dimensions of the plume were as follows.

Downwind Distance (meters)	Dimensions (meters)	
	σ_y	σ_z
100	8.0	4.5
200	11.3	5.8
400	17.8	7.5
800	27.7	9.7

Dose measurements were made using thirty 0 to 1 mR ionization chambers. A background exposure rate of 57.2 uR/hr was measured at Test Grid 3 where the test was held.

The doses measured at the 200 and 400 meter arcs were roughly twice background. With background subtracted the error on each measurement is estimated to be ± 27 uR. The doses measured on the 800 meter arc were mostly less than background.

The centerline doses at the 200 and 400 meter arcs were measured to be 31 uR and 22 uR respectively. The centerline doses predicted by arc using the above values of σ_y and σ_z were 86 uR and 63 uR at the 200 and 400 meter arcs respectively. The RSAC value for the centerline on the 800 meter arc is 56 uR.

The doses measured off the center line of the 200 and 400 meter arcs indicate that the crosswind distribution of the contaminant in the plume was more nearly uniform than gaussian. The off-center-line doses predicted by RSAC for all three arcs contained at least one dose that was higher than the centerline dose. This apparent anomaly has not been resolved.

Because of the low signal-to-noise ratio, the probable non-gaussian distribution in the plume and the anomalous behavior of RSAC no conclusions can be drawn from the test. Its main value was that it turned up problems which

when solved will allow us to perform better field tests in the future.

b) Twelve recording ionization chamber rate meters have been purchased and will be calibrated and placed in the field for reliability testing and background measurements.

c) It has been decided to produce radioactive for the study sources in the MTR. Purchasing sources of noble gases in the quantities needed is prohibitively expensive. A source release mechanism is being constructed in the Laboratory. The mechanism is based on a design by BNWL. The source for high gamma ray energy measurements will be ^{24}Na, for medium gamma ray energies ^{64}Cu and for low energies, ^{139}Ba.

d) A proposal for the erection of 4-500 foot towers at Test Grid 3 was prepared and submitted to the GPP board of ID. The proposal was not approved for FY 1969, but if the study is funded by DRDT there is an excellent chance that the towers will be erected early in FY'70.

e) The parametric study should be completed by April or May 1969.

f) Several dry runs of source irradiation, preparation and actual release will be carried out in April, May and June 1969.

19. EXPECTED RESULTS IN FY 1970

a) Equipment and techniques of data analysis should be developed for the measurement of gamma energy flux by July or August 1969.

b) The dose build-up study should be complete by December 1969.

c) The additional towers and associated electrical work for Test Grid 3 may be completed by November 1969. By the same date it is hoped to have the entire radiation detection system operational. Both of these estimates are based on the time that GPP funds and instrument funds are made available to ID. It is reasonable to expect that the field testing program will be well underway by the middle of FY 1970.

22. Description and Justification of Major Materials, Subcontract Items and Other Unusual Significant Cost Items.

FY 1969

Support Services

The cost of $10,500 includes funds for the services of INC personnel for their work on the development of techniques for gamma energy flux measurements and some source preparation and for PPCo's parametric study and the dose build-up factor study.

FY 1970

Support Services

The cost of $28,000 includes funds for the services of INC personnel for their participation in the dose build-up factor study, the field experiments and for source preparation and for PPCo's participation in the dose build-up factor study and field experiments.

Equipment Obligations

The funds for equipment and justifications are itemized below. Because of known fiscal restraints no equipment funds are requested in FY 1969. However, if funds can be made available in FY 1969 it would be wise to begin the equipment procurement as soon as possible.

(a) Ionization Chamber rate meters — 24 @ $600 — $14,400

These ion chambers will be the primary dose measuring devices for the study. We already have 12 of these chambers which we plan to test soon. We believe that recording the output of these devices every few seconds and integrating the dose rates mathematically is the most sensitive method of measuring the net radiation exposure.

(b) Cable for the above chambers $ 8,000

(c) Digital System for automatically interrogating 25,000
and recording the output of the 36 rate meters.
By automatically interrogating and recording the
outputs of the ratemeters for subsequent computer
processing, we save considerably over the cost of
hand collecting and processing. Strip chart recorders
alone would cost about $25,000.

(d) Three @ 300-ft towers and associated wiring.
The need to measure the vertical distribution 32,500
of the plume has been discussed above. In addition
to these towers which will be placed at the 200-meter
arc of Test Grid 3 we plan to have four @ 500-ft
towers erected at 600 meters. The cost of these
towers and the necessary wiring is estimated to be
$129,000 which we hope to fund as a GPP project.

(e) Hi-volume air samplers 140 @ $50 $ 7,000
These samplers will be supported by the towers and will
serve to measure the vertical distribution of the plume.
We plan to have special filter holders constructed to
place directly onto the sampler motor thus saving about
$80 per sampler over the cost of the on-the-shelf
samplers available.

FY 1971

Support Services

The cost of $27,000 includes funds for the services of INC personnel for their participation in the field experiments, source preparation and model building and for the Services of PPCo personnel for participation in the field experiments and model building.

FY 1972

Support Services

The cost of $15,000 includes funds for the services of IMC and PPCo personnel for the completion of the field experiments and model building.