HEALTH PHYSICS AND SAFETY DIVISION

32326

ANNUAL REPORT OF THE BROOKHAVEN DCPA CONTRACT GROUP*

Nathaniel A. Greenhouse

*J. Baum, N. Greenhouse (Project Director), A. Hull,
G. Levine, L. Phillips and R. Williams

July, 1974

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 1173

BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York 11973

HEALTH PHYSICS AND SAFETY DIVISION
Informal Report

ANNUAL REPORT OF THE BROOKHAVEN DCPA CONTRACT GROUP*

Nathaniel A. Greenhouse

* J. Baum, N. Greenhouse (Project Director), A. Hull,
G. Levine, L. Phillips and R. Williams

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Annual Report of the Brookhaven DCPA Contract Group*

Nathaniel A. Greenhouse
Health Physics and Safety Division

I. Summary

The DCPA Contract Group at Brookhaven National Laboratory was organized in May, 1973, in response to the needs of the Defense Civil Preparedness Agency. Its primary objective has been the development of a dual-use RADEF capability through programs designed to effectively utilize Civil Defense instrument and manpower resources in response to peacetime radiation accidents.

During the past year, the contract group has focused on reactor accident response and the assessment of radioactive effluents in the environment which directly affect public health. Additional efforts were directed at modification of C-D instruments for improved characteristics or to perform special functions, evaluation of RADEF resources in transportation accident response (Appendix III), and the evaluation of DCPA and state RADEF courses for peacetime application (Appendix IV).

This report presents the details of these studies in chronological order.

II. Alarming Radiation Monitor

In response to a special request from DCPA Region 1, an AC-powered alarm module was designed for use with the C-D end-window G-M survey meter, type CDV-700M (Figure 1). It will respond to fission gases at or below accepted Radioactivity Concentration Guides (RCG), and can provide a backup system for early notification in the event of a major release of radioactivity from a nuclear power reactor. The device can be set to alarm at any exposure rate, up to 50 mR/hr. In the event of a power failure, the alarm circuit (Figure 2) would become inoperative, but the count rate meter would continue to operate for about 30 hours on a set of enclosed, fully-charged batteries.

This prototype was developed in response to a unique request; and techniques for cost-cutting and design optimization were not investigated. However, the application concept for this type of instrument has become important to a reactor accident monitoring scheme which is developed in detail later in this report. For this application, the modification and use of the existing CDV-457 A.C. operated G-M count rate meter is proposed.

III. Improvement of Ion Chamber Instrument Sensitivity

Environmental monitoring following a reactor accident generally requires

* Research carried out at Brookhaven National Laboratory under contract with the U. S. Atomic Energy Commission.

ALL RESISTORS 1/4WATT UNLESS INDICATED.
 • = TIE POINTS

CDV-700
 MODEL 6B

FIGURE 2

field monitoring instruments of great sensitivity and selectivity. On-site hazards evaluations generally do not demand such stringent performance requirements until the site boundary is approached, where public health considerations become the limiting concern. In the latter case, Civil Defense ion chamber instruments lack sufficient sensitivity, by at least an order of magnitude. Therefore, experimental studies were pursued to bridge the gap between these instruments and the more sensitive G-M instruments.

Preliminary investigations have been conducted to determine the feasibility of increasing the sensitivity of the CDV 715 by using a gas of higher density at higher pressures. A chamber was subjected to increasing pressure. At 15 psi there was no indication of deformation; at 30 psi slight deforming was noted, and at 65 psi the chamber ruptured.

To determine the saturation characteristics of various gases at elevated pressures, a spherical ionization chamber was connected to a vibrating reed electrometer and data taken at a dose rate of about 100 mR/hr. In addition to air, the gases used were Freon-12, with a density of 5.3 and SF₆ with a density of 6.5. Xenon gas may be tested when it is available. The data is presented in Figure 3. Of the gases tested it appears that Freon-12 is the most promising. The response of SF₆ did not increase as expected, and this is probably due to its being a highly electro-negative gas and recombination is taking place.

IV. Instrument Modifications for Alpha Contamination Monitoring

An evaluation was made of existing and modified C-D instruments (i.e., the CDV-700M, end-window G-M, and the alpha-modified CDV-715 ion chamber) for detecting alpha contamination. Neither was considered adequate for field-monitoring of alpha emitters. The end-window G-M, while intrinsically sensitive enough, is only marginally capable of discriminating against a normal beta-gamma background when the alpha contamination is below several hundred dpm/cm². Another serious problem is the window's small surface area, which does not compare favorably with the large surface area of most alpha probes. The thin aluminized mylar window of the modified CDV-715 has a much larger surface area, however, this instrument suffers from low sensitivity, a long time-constant on the most sensitive scale and the fact that it operates on a continuous current mode, as opposed to pulse counting. This instrument has both low gamma sensitivity and low alpha sensitivity. When a 3×10^3 dpm alpha source was placed under the window in the "optimum" geometry, it produced a barely detectable meter deflection; thus, significant levels of plutonium

(i.e., $> 10^4$ dpm/probe area) might easily remain undetected under typical field-monitoring conditions. Another serious disadvantage of this instrument is that it is an electrometer (rather than a count rate meter) which precludes an audio output. Audio output is a very valuable feature for any alpha-monitoring instrument intended for field use, since the surveyor must watch both where he is walking and the surface which he is monitoring. He must also maintain the critical distance between the probe and the contaminated surface. Thus, continuous observation of the meter is nearly impossible. An audio output also enhances the ability of the surveyor to detect low count rates, which are difficult to observe on a meter. For all these reasons, we recommended using an alpha scintillation or proportional counter probe with a CDV-700. This is a more sensitive instrument and it has an audio output for earphones or a separate speaker accessory.

An adequate modification for the CDV-700 was developed at Brookhaven several years ago, and is described in BNL 17409 (App. I). It uses a commercially available alpha scintillation probe, and is in routine use for alpha contamination monitoring at the Laboratory.

V. Environmental Monitoring Following a Reactor Accident

A. Monitoring Concept

One of the approaches considered in an original proposal to develop DCPA resources for peacetime applications involved the postulation of several accident situations from which the basic performance requirements for portable monitoring instruments could be determined. This approach was abandoned in favor of the direct assessment of radiological parameters affecting the public health based on published "action levels". I.e., minimum instrument performance specifications should be based on the capability to provide reliable monitoring information at the action levels.

Since thyroid irradiation from radioiodine uptake appears to be the critical source of exposure to the public following a major reactor accident, attention should be focused on action levels for thyroid exposure and monitoring techniques for thyroid dose prediction. The Federal Radiation Council (FRC) has suggested a Protective Action Guide for ^{131}I of 30 rads to the thyroid of an individual in the general population⁽¹⁾. New York State has established a protective action level for thyroid exposure at 10 rads⁽²⁾. Most recently, the Environmental Protection Agency

(EPA) proposed a minimum protective action guide of 1 rad to the thyroid⁽³⁾. As a starting point, a 10 rad thyroid dose commitment to a 1-year old child was selected as a basis for the development of an emergency environmental monitoring scheme. This would be the result of inhalation of an equilibrium mixture of ^{131}I (1 hour decay) at concentration of about 10 d/m cm³ of air for 2 hours, or the ingestion of milk contaminated with ^{131}I at 65 nCi/l. (Derivations are given in Appendix II.) These parameters form a basis then for radioiodine monitoring in the field, and for establishing the adequacy of Civil Defense instruments to perform the task.

The most urgent pathway which determines protective action requirements in the event of a reactor accident is the direct inhalation and resultant thyroid uptake of radioiodine. Given an airborne radioiodine concentration of 10 dpm/cm³, a charcoal-impregnated filter paper air sampler operating at 5 cfm and 50% collection efficiency, and a counting efficiency of 1% for a CDV-700M end-window G-M survey meter, the count rate on monitoring the filter after sampling for 5 minutes is about 3.5×10^4 cpm. This will result in a slightly greater than full scale deflection on the CDV-700M count rate meter. Thus, it appears that a simple air sampler could provide a rapid means of assessing airborne radioiodine concentrations well below those corresponding to any of the currently accepted or proposed protective action guides. Deployment of air samplers in and around population centers near power reactor installations can provide a rapid means of verifying that a release has taken place, and a "go or no-go" indication that the release was of sufficient magnitude to exceed protective action guides.

Since it would be impractical to operate an air sampler on a continuous 168-hour a week basis, a sensing device or some system of notification is needed to turn the sampler on automatically, or to inform radiation monitoring personnel to turn it on manually. This system should be completely independent of administratively controlled communications channels. The following scheme is proposed to perform this function:

In a major release from a reactor, the ratio of noble gas to iodine curies will generally be substantially greater than 10:1.

The Safety Analysis Report for the Brookhaven High Flux Beam Reactor⁽⁴⁾ indicates a ratio of about 30:1. In this case, the total fission gas activity concentration at the radioiodine action level is of the order of 300 d/m · cm³. A semi-infinite cloud at this concentration will produce an effective exposure

rate of the order of 50 mR/hr; i.e., well within the detection range of a CDV-700 or CDV-457 (A.C. operated GM count rate meter). Thus, a CDV-457 can be used to activate an alarm upon detection of the fission gas cloud, and provide the queue to begin air sampling and radioiodine.

B. Description of a Prototype Monitoring System

The system as envisioned would be deployed on a large scale, nationwide basis in continuously manned facilities such as fire houses and police departments. In the interest of economy, it should utilize existing resources as much as possible and require a minimum of specially purchased supplies and modifications to existing instruments. To this end, existing home or shop type vacuum cleaners are suggested as air movers for the radioiodine air sampling system. A survey of privately owned vacuum cleaners ranging in age from less than one year to over twenty years demonstrated their adequacy in this application. Flow rates through the air sampling head ranged from 7 to 22 cfm. The highest flow was produced by an inexpensive shop-type vacuum cleaner. (A small battery-powered automobile vacuum cleaner operated at 2.5 cfm under load. Although this is below the assumed minimum flow of 5 cfm, the system appears to have ample sensitivity such that an auto vacuum would still be usable in monitoring situations where portability is desired.)

The prototype air sampling heads are shown in Figures 3 and 4. The unit labeled "A" (Figure 3) is an inexpensive commercially available filter holder made of injection molded plastic. Unit "B" was machined from PVC and was designed to hold a standard American Optical Corp. type R-51 charcoal-loaded respirator cartridge. The tapered connection was designed to provide a universal fit to a vacuum cleaner hose. Although unit "A" did not have a tapered fitting, both units remained firmly seated in the vacuum cleaner hoses during operation.

The inside diameter of the lucite mask (Fig. 4) corresponds to the outside diameter of the CDV-700M and is designed to insure a uniform and reproducible counting geometry when monitoring the collection media for radioiodine. In addition, it restricts air flow to the center of the filter and concentrates any collected radioiodine to that area with a resultant improvement in counting efficiency.

Two collection media were tried: the aforementioned AO type R-51 cartridge;

FIGURE 3

Figure 4

and an MSA Dust Filter (Bur. of Mines No. 2133) which is a charcoal impregnated fiber filter trimmed to fit into unit "A". The system was calibrated by generating an aerosol of ^{128}I (25 min. half-life), collecting air samples under various conditions on the two media, establishing the activity collected with a scintillation gamma spectrometer, and comparing this result with the observed count rates on a CDV-700M. Beta counting efficiencies were assumed to be the same for ^{128}I and a one-hour old equilibrium mixture of ^{131}I through ^{135}I . Corrections were made for decay and differences in beta yields. The calculations are presented in Appendix II. Calibration results are listed in the table below.

<u>Calibration Conditions</u>	<u>Calibration Factor (cpm/μCi)</u>	<u>Counting Efficiency</u>
R-51 with mask	1.1×10^4	0.5%
R-51 without mask	1.5×10^3	0.7%
2133 with mask	4.3×10^4	1.9%
2133 without mask	1.7×10^4	0.8%

It appears that an inexpensive charcoal-loaded fiber filter yielded the best compromise between iodine collection efficiency ($\approx 50\%$) and beta counting efficiency ($\sim 2\%$).

There is reason to believe that radioiodine released in reactor effluents may be enriched in organically bound chemical species such as methyl iodine, since elemental iodide is highly reactive and would tend to be selectively scavenged from the effluent. The radiological hazards from inhalation of methyl iodide or elemental iodine appear to be roughly equivalent⁽⁵⁾; therefore, the air sampler collection efficiency for these two species should be about equal for proper hazards assessment from the monitoring data. The efficiency for these two species should be about equal for proper hazards assessment from the monitoring data. The efficiency of the R-51 cartridge for both these chemical forms is excellent; however, the efficiency of the 2133 filter for methyl iodide is not known at this time. Silver zeolite is known to have a high absorption efficiency for organically bound iodine. An inexpensive fiber filter loaded with this substance and activated charcoal may be the most economical solution.

The contribution of radon/thoron daughters to the background count rate was considered as a possible source of interference in radioiodine monitoring.

At typical ambient air concentration of the order of 10^{-10} $\mu\text{Ci}/\text{cm}^3$ there will be less than 100 pCi of radon/choron daughters in a 25 cubic foot air sample (5 cfm for 5 minutes). This activity would contribute much less than 100 cpm to the background count rate and is therefore not deemed a significant source of interference at any of the proposed radioiodine action levels.

Background radiation from the fission gas cloud could also interfere with attempts to monitor the accumulated radioactivity on the filter since the count rate on a CDV-700M from a semi-infinite cloud could be the same order of magnitude as that from the filter when radiiodines are present at the protective action level. Therefore, the filter should be monitored indoors and preferably in an enclosed and poorly ventilated area. Ideally, the background count rate on the CDV-700M should be less than 500 cpm in order to see radioiodine at the EPA's most restrictive proposed action level. In the case of well ventilated buildings, it may be necessary to build a small simple counting cave of conventional construction materials in order to achieve sufficiently low background count rates in the presence of high concentrations of the fission gases.

C. Suggested Deployment Scheme

Field monitoring station and procedures should be established and coordinated with state and local emergency plans for radiation accidents. Ideally, the stations should be facilities such as firehouses or police precincts which are located in or near population centers in the vicinity of nuclear power generating facilities and are manned 24 hours a day. The alarm-modified CDV-457 should be sheltered from the weather but located in an open area (preferably elevated) which is accessible to ambient wind currents. On receipt of the alarm signal, designated personnel would attach an air sampling head to the facility's domestic or shop-type vacuum cleaner, and proceed to sample ambient air in open areas (preferably outdoors) for five minutes. While the air sample is being taken, the area should be surveyed with the CDV-700M to find a low-background location where the filters can be monitored. The filters may then be counted in the assembled sampling head by holding the CDV-700M probe in contact with the filter medium and using the mask as a positioning guide. If the background count rate is less than 500 - 600 cpm, a full-scale reading on the "x 100" scale would indicate a possible thyroid dose commitment in excess of 10 rads based on inhalation of radioiodine-contaminated air for two hours. Likewise, a full-scale reading on the "x 10" scale would indicate a dose commitment in excess of

1 rad. State and/or local public health authorities or their designees should be immediately notified of the monitoring results and especially of any positive readings. Air sampling should be repeated every 15 to 20 minutes until background radiation levels return to normal, or per the instructions of the proper authorities.

R E F E R E N C E S

1. Federal Radiation Council (1964). Background Material for the Development of Radiation Protection Standards. Federal Radiation Council, Report No. 5. U. S. Government Printing Office, Washington, D.C.
2. New York State Emergency Plan (1973). Specific Operating Procedures, Brookhaven National Laboratory Site. New York State Department of Health, Bureau of Radiological Health, Albany, N.Y.
3. Environmental Protection Agency (1974). Draft Emergency Action Guidelines and Protective Measures for Nuclear Incidents. EPA, Office of Radiation Programs, Washington, D.C.
4. Henrie, J.M. (1964). Final Safety Analysis Report on the Brookhaven High Flux Beam Research Reactor. BNL 7661, Vol. II., Brookhaven National Laboratory, Upton, N.Y.
5. Bunch, D.F. (1969). The Comparative Environmental Hazards from a Release of Methyl Iodide or Elemental Iodine. Health and Safety Division, Idaho Operations Office, U. S. A.E.C., Idaho Falls, Id.

APPENDIX I

CONVERSION OF VICTOREEN MODEL 6 CDV 700 GM INSTRUMENTS
FOR USE WITH SCINTILLATION OR BF_3 PROBES*

Budd S. Pollock and Edwin Hagelberg
Health Physics and Safety Division
Brookhaven National Laboratory
Upton, New York 11973

The Victoreen Model 6 of the CDV 700 series instruments can be converted to accept an alpha or thermal neutron detector, and still retain the original GM beta gamma capability. The CDV 700 series of instruments were made by a number of manufacturers, each using different circuitry. With each production run some modifications were made to improve reliability, reduce costs, lower battery drain or meet changing specifications.

The Victoreen Model 6 was selected because it had adequate battery capacity, convenient space and easily adaptable circuitry. It is possible that other CDV 700 series instruments could also be modified; however no effort has been made by us along these lines. The required modifications are:

- 1) Remove GM tube cable from fastening on body of instrument.
- 2) Enlarge hole to take connector UG1094/U insulated from chassis. The case is made of magnesium; drill quickly; fire hazard.
- 3) Add a preamplifier as shown in BNL drawing number IH 424-1. It may be mounted in the space between the battery holders. The input connections to the preamplifier must be supported on teflon insulators, and shielded cable is run from the instrument input connector to the preamplifier and from its output to a convenient point for connection to existing circuitry.
- 4) The circuit shown provides additional filtering and adjustability of the high voltage supply. In the case of an Eberline Alpha Scintillation probe, the high voltage is adjusted to a point just below where it starts to count in a gamma field of approximately 60 mR/hr.
- 5) If it is desirable to retain GM tube capability, a second connector and a small toggle switch may be added in the

*Research carried out at Brookhaven National Laboratory under contract with the U. S. Atomic Energy Commission.

space just forward of the newly mounted connector. This connector need not be insulated from the chassis. The switch disables the preamplifier. The circuit diagram indicates the parts required in addition to the existing circuit.

- 6) If a thermal neutron detector probe such as a Harshaw 12 cm depleted BF_3 tube is to be used, the preamplifier is required and the high voltage must be raised. The regulator tube, V2, is selected to provide the proper operating voltage for the BF_3 tube being used.
- 7) A diode, 1N100, may be added between the base of the first transistor to the ground bus in the preamplifier, for protection against large transients on the input. The preamplifier draws about 1.4 milliamperes from the existing 6 volt battery pack, and will amplify 5 millivolt pulses to the level required to trigger the blocking oscillator in the basic instrument. Due to minor differences in manufacturing tolerances, it may be necessary to adjust the input sensitivity of the rate meter section of the instrument. If it is determined that the blocking oscillator requires more than -0.5 volt or +1.0 volt pulse to trigger, the cut-off bias on Q1 should be adjusted by changing the values of R9 and R10 or replacing CR1 or Q1.

Four years experience with this modification in the field has proven it to be reliable, as well as increasing the usefulness of the instruments.

- NOTE:**
- 1- ALL TRANSISTORS 2N1711.
 - 2- RESISTORS 1/4 WATT UNLESS OTHERWISE INDICATED.
 - 3- R, SELECTED FOR PROPER ALPHA PROBE VOLTAGE, ~60V. DROP/10M ADDED.

SERVICE NOTE: VOLTAGES TO GND - 20KΩ/V METER, 12V RANGE.

* VICTOREEN INSTRUMENT CD V 700 MODEL #6

APPENDIX II

Problem #1 - Airborne iodine concentration necessary to yield a 10 rad thyroid dose commitment (via inhalation) to an infant in 2 hours.

- 1) Adult thyroid dose commitment from uptake of 1 μCi of equilibrium mixture of ^{131}I to ^{135}I with 1 hour decay is 1.60 rad.

Isotope	Fractional Thyroid Uptake		Dose Commitment (rad)	
	10 min Decay (a)	1 hr Decay (b)	10 min Decay (a)	1 hr Decay ^(from a & b)
^{131}I	0.113	0.138	0.730	0.892 55.6%
^{132}I	0.163	0.157	0.039	0.038
^{133}I	0.253	0.303	0.439	0.526 32.7%
^{134}I	0.249	0.157	0.028	0.018
^{135}I	0.222	0.245	0.118	0.130
Total	1.0	1.0	1.354	1.604

(a) From BNL 819, table 5, page 7

(b) From memo: A. Hull to L. Phillips, 10/23/73, table I.

- 2) μCi thyroid uptake to yield 10 rad adult dose commitment:

$$10 \text{ rad} / 1.6 \text{ rad}/\mu\text{Ci} = 6.25 \mu\text{Ci}$$

- 3) Fraction of inhaled iodine reaching thyroid = 0.23 (From ICRP Comm. II, H.P. Jour. Vol. 3, page 183.

- 4) $6.25 \mu\text{Ci} / 0.23 = 27.2 \mu\text{Ci}$ inhaled by adult to give 10 rads.

- 5) Assume uptake of iodine by 1-year old child approximately the same as an adult (FRC #5, page 11).

$$27.2 \mu\text{Ci} \times \frac{2 \text{ gr (child thyroid)}}{20 \text{ gr (adult)}} = 2.72 \mu\text{Ci inhaled by 1-year old to give 10 rads}$$

- 6) Respiration, 1-year old child: (From Rad Health Handbook, page 216)

$$1200 \text{ l}/14 \text{ hr (resting)} + 3500 \text{ l}/10 \text{ hr (lt. work)} = 4700 \text{ l}/24 \text{ hr (avg)}$$

- 7) Average airborne concentration of equilibrium mixture of ^{131}I - ^{135}I (1 hr. decay) to give 1-year old child 10 rad dose commitment from a 2 hour inhalation exposure:

$$\text{Resting: } 1200 \text{ l}/14 \text{ hr} = 171.4 \text{ l}/2 \text{ hr}$$

$$\frac{2.72 \mu\text{Ci}}{171.4 \text{ l}} = 0.0159 \mu\text{Ci}/\text{l}$$

$$= 35.3 \text{ d}/\text{m}\cdot\text{cm}^3$$

$$\text{Lt. Activity: } 3500 \text{ l}/10 \text{ hr} = 700 \text{ l}/2 \text{ hr}$$

$$\frac{2.72 \mu\text{Ci}}{700 \text{ l}} = 0.00389 \mu\text{Ci}/\text{l}$$

$$= 8.64 \text{ d}/\text{m}\cdot\text{cm}^3$$

Suggest one assume the worse case for monitoring and round off to 10 d/m·cm³.

Problem #2 - Iodine surface activity/m² of forage which could result in 10 rad thyroid dose to an infant via the milk pathway.

- 1) 65 nCi ¹³¹I/l milk yields 10 rad dose commitment to child. (From FRC Report #5, page 14)

(Assume all dose to child from milk intake due to ¹³¹I.)

- 2) 0.11 μCi ¹³¹I/l milk from 1 μCi ¹³¹I/m² on ground. (From IAEA Safety Series #18, page 60)

$$3) \therefore \frac{0.065 \mu\text{Ci}/\ell}{0.11 \mu\text{Ci}/\ell / 1 \mu\text{Ci}/\text{m}^2} = 0.59_1 \mu\text{Ci } ^{131}\text{I}/\text{m}^2$$

- 4) However, at 24 hours (1 day) post release:

41% of iodine activity is due to ¹³¹I (0.36 MeV, 82%)

45% of iodine activity is due to ¹³³I (0.53 MeV, 90%)

$$\frac{0.59_1 \mu\text{Ci } ^{131}\text{I}/\text{m}^2}{0.41} = 1.44 \mu\text{Ci } \text{I}/\text{m}^2 \text{ on ground}$$

$$1.44 \mu\text{Ci}/\text{m}^2 \times 2.22 \times 10^6 \text{ d}/\text{m} \cdot \mu\text{Ci} \times 10^{-4} \text{ m}^2/\text{cm}^2 = 320 \text{ d}/\text{m} \cdot \text{cm}^2$$

(From memo A. Hull to L. Phillips, 10/12/73, table I)

- 5) 0.45 MeV γ results in ~ 10 R/hr/Ci/m² (From IAEA Safety Series #18, page 68)

$$10 \text{ R/hr/Ci}/\text{m}^2 \times 1.44 \mu\text{Ci}/\text{m}^2 \times 10^{-12} \text{ Ci}/\mu\text{Ci} = 14.4 \mu\text{R/hr},$$

or ~ 15 μR/hr at 3' above the ground.

Problem #3 - Given air concentrations in Problem #1, and a charcoal impregnated filter paper air sampler operating at 1 cfm and 100% efficiency, can this activity be detected by the conventional end window portable GM instrument?

Assumptions

- 1) Flow Rate = 1 ft³/min = 28,320 cm³/min
- 2) Collection Efficiency = 100%
- 3) One hour sampling time
- 4) 1 beta particle/disintegration
- 5) Continuous and constant air contamination
- 6) Instrument geometry = 10%

$$\frac{0.00389 \mu\text{Ci}/\ell}{10^{-3} \text{ cm}^3/\ell} \times 28,320 \text{ cm}^3/\text{min} \times 60 \text{ min/hr} = 6.6 \mu\text{Ci Iodine}$$

$$6.6 \mu\text{Ci} \times 2.22 \times 10^6 \text{ d}/\text{m} \cdot \mu\text{Ci} \times 0.10 \approx 1.5 \times 10^6 \text{ counts/min.}$$

Problem #4 - Given surface contamination in Problem #2, is it feasible to directly monitor a cow's thyroid and/or milk using a conventional end window GM instrument?

- 1) For Milk: (From IAEA Safety Series #18, page 85)

	<u>counts/m/μCi/ℓ H₂O</u>	<u>counts/m/65 nCi/ℓ</u>
1 ℓ	500	32
5 ℓ	800	52
≥ 10 ℓ	1000	65

(Problem 4, Cont'd.)

∴ "marginal" - scintillation detector would be better.

2) For Cow's Thyroid: (From memo A. Hull to L. Phillips, 10/12/73)

12 pCi ^{131}I /gr cow thyroid yields 1 pCi/l milk

Cow thyroid $\approx$ 50 grams

12 pCi/gr $\times$ 50 gr = 600 pCi in thyroid to yield 1 pCi/l milk

$$600 \times 65 \times 10^3 = 3.9 \times 10^7 \text{ pCi} \approx 39 \mu\text{Ci}$$

$$^{131}\text{I} \approx 2.2 \text{ R/hr/mCi at } 1 \text{ cm} \approx 2.2 \times 10^{-2} \text{ mR/hr } \mu\text{Ci at } 10 \text{ cm.}$$

Assume zero attenuation in 10 cm

$$0.022 \text{ mR/hr} \cdot \mu\text{Ci} \times 39 \mu\text{Ci} = 0.86 \text{ mR/hr}$$

Problem #5 - System Calibration Against ^{128}I

Sample calculation for Bur. Mines 2133 dust filter with "mask".

$$\text{Activity on filter at } t_2: 0.123 \mu\text{Ci} \times 0.936 \frac{\text{B dpm}}{\mu\text{Ci}} = 0.115 \mu\text{Ci} \\ (\text{from counting lab data})$$

$$\text{CDV-700M count rate at } t_1: 3.5 \times 10^4 \text{ cpm}$$

Decay Factor, t_1 to t_2 : 0.57

$$\text{Corrected count rate to } t_2: 0.57 \times 3.5 \times 10^4 \text{ cpm} = 2.0 \times 10^4 \text{ cpm}$$

$$\text{Calibration factor for "2133 with mask": } \frac{2 \times 10^4 \text{ cpm}}{0.115 \mu\text{Ci}} = 1.7 \times 10^5 \frac{\text{cpm}}{\mu\text{Ci}}$$

$$\text{Efficiency: } \frac{2 \times 10^4 \text{ cpm}}{0.115 \mu\text{Ci} \times 2.2 \times 10^6 \frac{\text{dpm}}{\mu\text{Ci}}} = 7.9 \times 10^{-3} \frac{\text{cpm}}{\text{dpm}}$$

$$\approx 0.8\%$$

APPENDIX III

Considerations Regarding Utilization of RADEF Resources in Transportation Accidents

The contract group has examined the transportation accident as a possible class of situation in which Civil Defense personnel (volunteers) and DCPA instruments (CDV-700, CDV-715, etc.) might be utilized.

The final conclusions are based on two aspects. The first is based on DOT packaging requirements, where the overriding principle is that hazardous materials (as determined by toxicity and quantity) must be protected in transit so as to preclude the release of such material. Packages which are approved for this "high hazard" material must be able to withstand the following environmental test conditions (among others).

1. a 30 foot fall to an unyielding surface
2. 40 inch drop onto the top end of a 6 inch diameter vertical steel bar
3. heating in 1475 environment for 30 minutes

The point is that a transportation accident involving the shipment of "high hazard" material is simply not likely to release any radioactivity. This contention is borne out in a recent AEC Report, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants" (WASH-1238).

If, on the other hand, the material is not "high hazard" (in toxicity and quantity) the package requirements are not nearly as stringent and the material may be released from its container in a transportation accident. In this case, there is no immediate need for a radiation survey since it is in no way "life threatening". After first aid and life saving actions are completed and access is controlled, there is no urgent requirement to clean up the area. In this case, time is available to wait for a training health physicist to arrive to do detailed hazards analysis and plan the clean up. In the latter case, RADEF personnel may be able to assist, but by virtue of their training and equipment they may be blind to problems that exist at the scene.

APPENDIX IV

DCPA Contract Training II

A representative of the BNL contract group (R. Williams) attended the Peacetime Radiation Incident Training (PRIT) course conducted by the California Office of Emergency Services (OES), in Santa Ana, from February 25 to March 1, 1974. The purpose was to evaluate the course as a potential model for peacetime incident training as required by the BNL DCPA contract.

The objective of the course was to provide emergency services personnel with the knowledge of hazards likely to result from radiation accidents, and guidance on managing these accidents. The course consisted of lectures, films, exercises, a tour, and discussions with representatives of many government agencies involved in either the regulation of radioactive materials or the response to incidents involving radioactive materials. (See attached schedule.) Completion of the RDO I course was a prerequisite for attendance.

The subject matter was quite comprehensive, and the notebook supplied with the course included good reference material. The exercises were realistic and pointed out the practical aspects of responding to the represented incidents. Discussions with government representatives were very informative.

On the whole, the OES course was an excellent example of peacetime radiological accident training. One of the problems involved in reproducing this course elsewhere would be in duplicating the caliber of the speakers used here, which, generally speaking, was outstanding.

The California PRIT course would serve as an excellent model for a peacetime radiation incident course to be developed for the DCPA contract.

OFFICE OF EMERGENCY SERVICES
PEACETIME RADIATION INCIDENT TRAINING

DATE/TIME

SUBJECT

MONDAY

8:30- 8:45	Registration & Introduction
8:45- 9:00	Welcome
9:00-11:45	Radiation Fundamentals
11:45-12:30	Lunch
12:30- 1:00	Film: "Fundamentals of Radioactivity"
1:00- 2:30	Biological Effects of Radiation
2:30- 4:45	Tour of Local Nuclear Facility

TUESDAY

8:00- 8:45	Role of Environmental Protection Agency
8:45- 9:30	Role of Atomic Energy Commission
9:30-10:15	Role of Radiologic Health Section
10:15-11:00	Role of Division of Industry Safety
11:00-11:45	Role of Local Jurisdiction and OES
11:45-12:30	Lunch
12:30- 1:00	Film: "Atoms on the Move"
1:00- 1:15	Posting Radiation Signs and Tags
1:15- 2:15	Department of Transportation Regulations
2:15- 3:45	Instruments (Primary Emphasis on Alpha Detection)
3:45- 4:45	Instrument Exercise
	Homework: Situation Problem No. 1

WEDNESDAY

8:00- 8:30	Review Homework Problem
8:30- 9:30	Film: "Enter with Caution - The Atomic Age"
9:30-10:45	Radiation Incident Plans
10:45-11:45	Nuclear Weapon Incident (Broken Arrow)
11:45-12:30	Lunch
12:30- 1:00	Film: "Response to Off-base Nuclear Accidents"
1:00- 3:00	Exercise I - Transportation Accident
3:00- 4:30	Exercise II - Lab Accident (Alpha Spill)
	Homework: Situation Problem No. 2

THURSDAY

8:00- 8:30	Review Homework Problem
8:30-10:15	Reactor Accidents - SL-1
	Film: "SL-1, Phase I & II"
10:15-10:30	Break
10:30-11:45	Nuclear Reactor Planning
11:45-12:45	Lunch
12:45- 1:15	Film: "Fire Fighting in the Nuclear Age"
1:15- 2:00	Review of Hospital and Lab Accidents
2:00- 3:30	Exercise III - Downed Aircraft
3:30- 4:30	Exercise IV - Hospital
	Homework: Situation Problem No. 3

FRIDAY

8:00- 8:30	Review Homework Problem
8:30- 9:00	Course Examination
9:00-10:00	Hospital Handling of Radiation Patients
10:00-11:30	Decontamination - Film: SL-1, Phase III
11:30-12:00	Review Examination, Critique, Closing