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ABSTRACT

A program to monitor airborne contamination in the working environment of a plutonium facility is discussed. Only those aspects most closely associated with operational monitoring are included and, as a result, several side topics in the realm of air monitoring are not mentioned.

Techniques, equipment, records, and philosophy are discussed, in addition to air concentration trends, equipment evolution, cost, manpower requirements, and inherent shortcomings.

For the present air monitoring program, 351 samples are collected daily on HV-70 filters at fixed locations in work areas and counted in automatic alpha counting systems. Counting results are interpreted in terms of air concentrations and recorded for evaluation by the health physics and operating staff. Also, 21 commercial continuous air monitoring devices are located throughout the work areas.

Air monitoring at the Los Alamos Scientific Laboratory (LASL) plutonium facility began in the mid-1940's when the facility started operation as the world's first production and fabrication facility for handling kilogram quantities of plutonium. The air monitoring program has since evolved into an adequate and practical program for accessing airborne contamination levels and for preventing inadvertent inhalation cases.

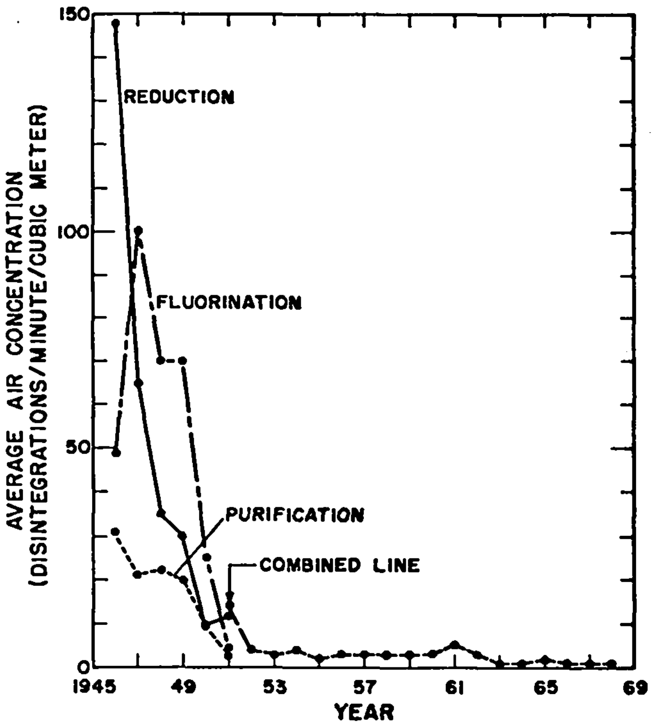

Fig. 1. Average air concentration trends.

INTRODUCTION

A brief review of past techniques and equipment seems appropriate in that 1968 marked the 25th year of plutonium handling at Los Alamos. The first quantity of plutonium large enough to be seen with the naked eye arrived in 1943 and plutonium handling increased from a few micrograms in 1943 to kilograms in 1945. This left less time than usual for development of safe handling methods and equipment. Production techniques were developed as the need arose on bench tops and inside conventional chemical fume hoods. Meanwhile, air sampling methods borrowed from other fields were used. Impingers, electrostatic precipitators, and filter paper samplers were used; however, filter paper soon gained acceptance for routine use. Realizing that it was impossible to take an air sample which truly represented a worker's exposure, we began a search for supplemental methods for evaluating personnel exposure. This resulted in the development of a plutonium urinalysis program which began in December 1944, and a nasal swab program in 1945.

The need for better confinement of contamination was soon realized and unventilated wooden dryboxes were introducted. The dryboxes rapidly became standard equipment for plutonium operations that were being conducted in D Building, a large temporary building. In 1946, a new production facility was built which allowed separation of production and laboratory work. This separation proved beneficial because control measures necessary for handling kilogram quantities of plutonium are not always required where microgram quantities are handled. This production facility has undergone several modifications since 1946 and continues to be the main LASL plutonium facility.

Airborne plutonium levels at the facility were reduced significantly between 1946 and 1951 as shown in Fig. 1. This was primarily due to the introduction of ventilated glove boxes and hoods and the elimination of open-air material transfers.[2,3] Equipment and techniques continued to improve and today airborne plutonium is seldom detected in work areas during normal operating conditions.

FACILITY DESCRIPTION

The LASL plutonium facility, known locally as DP West, consists of five buildings with approximately 40,000 square feet of operating area. These buildings are divided into nine wings connected by a spinal corridor which originates at an administration building. Six wings are devoted to plutonium work; the other three are used for enriched uranium recovery and production and for transplutonium element research.

Sixty-five individuals are directly involved in plutonium programs which include purification, metal production, fabrication, recovery, research, and development. Approximately 200 employees work at the facility. The plutonium programs involve a wide variety of operations which are conducted in well-ventilated and filtered metal glove boxes or enclosures. Even though kilogram quantities

Fig. 2. Filter Queen sampler.

of plutonium are handled, most of the work is for specialized programs and is developmental in nature. Only a few programs, such as purification, metal production, and recovery, can be classed as production.

MONITORING PHILOSOPHY

The basic philosophy behind air monitoring for plutonium has not supported the use of air sample results for the primary determination of personnel exposure. However, the philosophy supports an extensive program of sampling with filter paper at fixed locations throughout the work areas and the use of gross alpha continuous air samplers for the detection and warning of excessive levels.

The fixed samples are useful for determining the effectiveness of operational contamination controls and personnel exposure in a qualitative manner since general levels of airborne contamination are measured.

Urinalysis and *in vivo* counting techniques are the primary methods of determining personnel exposure for reporting purposes.

PRACTICES AND EQUIPMENT

A. Fixed Sampling

The Filter Queen sampler was used at other Manhattan Project installations prior to becoming the most common fixed sampling system at Los Alamos. The original Filter Queens and later versions were modified household vacuum cleaners (Fig. 2) that pulled air through a 4- x 9-in. filter. They could be moved about the area by one person but were generally left at a fixed location. Their disadvantages included high maintenance cost, the large area of filter paper required for a low pressure drop, noise, and use of floor space. The Filter Queen was used exclusively until 1957 when the installation of central sampling systems (Fig. 3) patterned after the Rocky Flats system was started. Installation of these systems permitted increased sampling in operating areas and the use of small diameter filter papers which could be counted in automatic counting systems.

The central sampling systems utilize 5 high-capacity vacuum exhausters, sized piping to sampling locations in operating areas, quick-disconnect filter holders (Fig. 4), and 2-1/8-in. filters. Air flow through the filter can be adjusted at each location and is checked weekly by the calibrated equipment shown in Fig. 5. A total of 351 locations are used for collecting daily routine samples. The normal sampling period is from 0830 to 1630; filters are replaced during the last 30 min of the work day. The used filters are collected in racks and stored in a clean area until they are counted the following day. Provisions are made for replacing the routine filters during the day

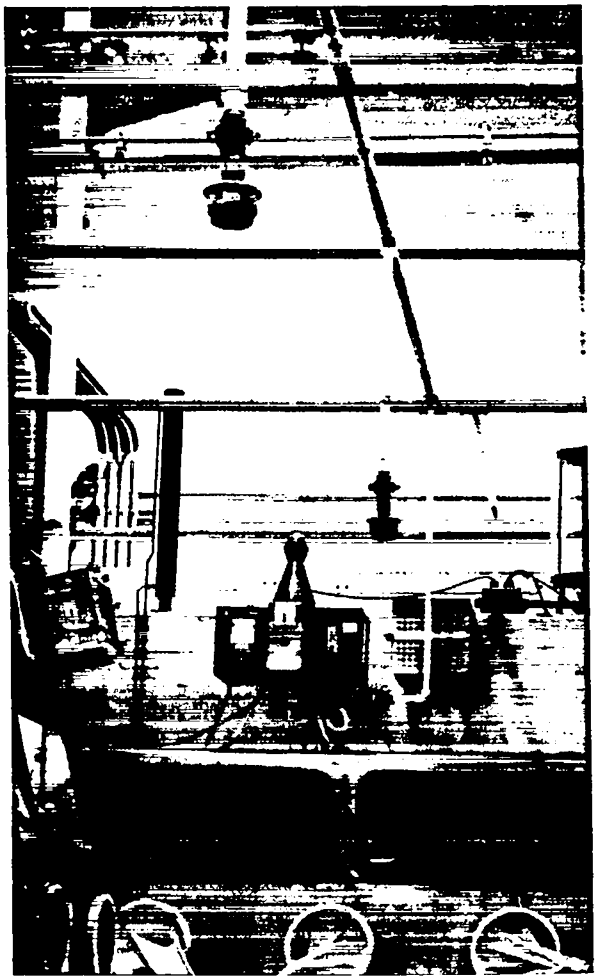

Fig. 3. Work area central sampling system.

and collecting "special" samples whenever operations of a nonroutine nature are conducted. Persons in the area wear respiratory protection during collection of special samples.

Sampling in normally unused areas outside the central sampling system is done with a portable "giraffe" sampler (Fig. 6). This sampler uses a filter holder and filter identical to that used on the central sampling system and is capable of sampling at 2 cfm.

B. Continuous Sampling

Early efforts were made to develop a continuous sampler capable of rapidly detecting excessive airborne plutonium because fixed sample results were not available un-

Fig. 4. Filter holders and rack.

til a day or so after collection of the sample. Figure 7 shows an early continuous sampler built and used at Los Alamos. It utilized a movable strip filter which advanced from the sample collection position to the scintillation detector every 10 min. When commercial samplers became available they were tried and adopted; 21 continuous samplers are now in use at the facility. In-

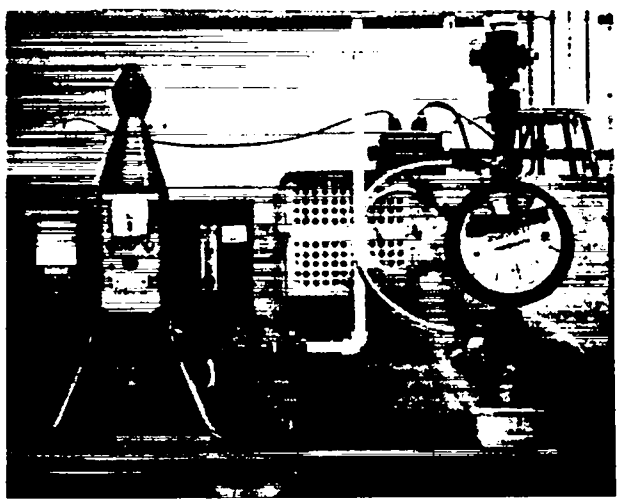

Fig. 5. Flow calibration.

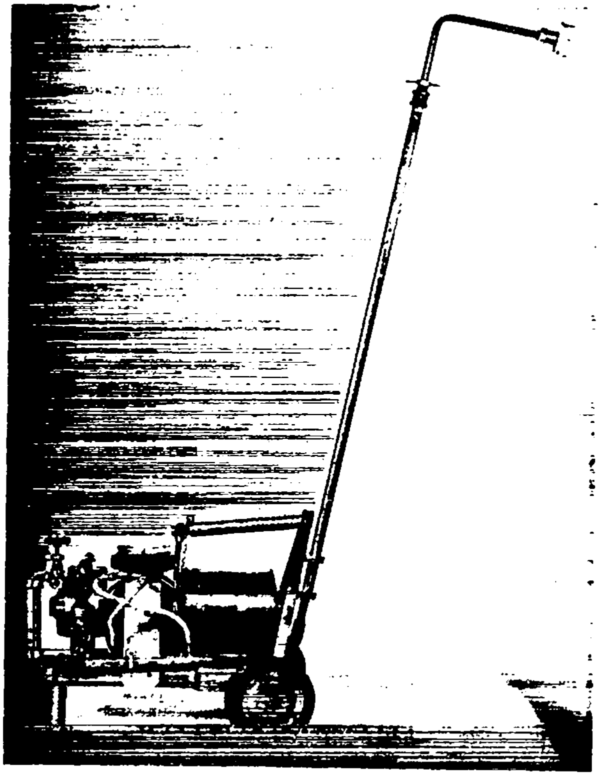

Fig. 6. "Giraffe" sampler.

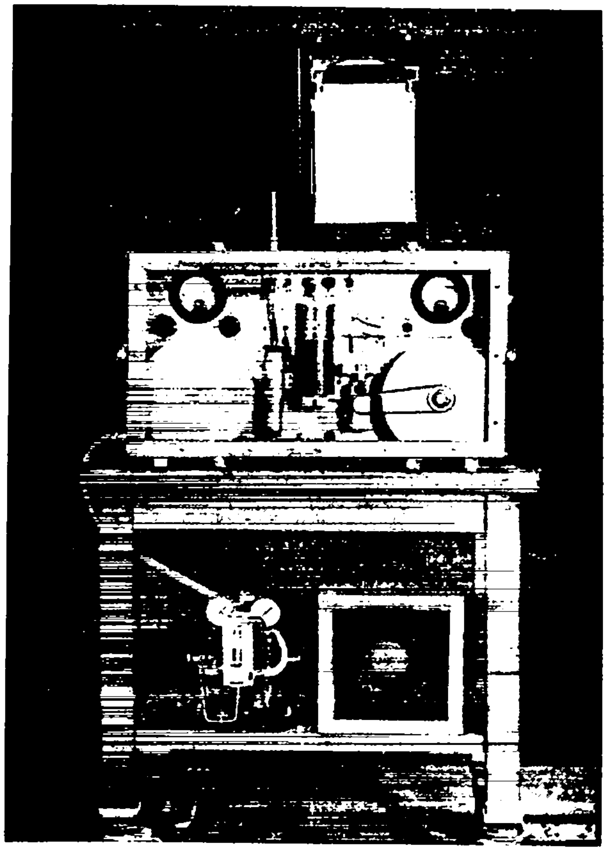

Fig. 7. Early Los Alamos continuous air sampler.

cluded are samplers from five different manufactors, all with fixed filters and gross alpha scintillation detectors in addition to local audible and visible alarms and recorders.

Most of the samplers are connected to outlets on the central sampling system to reduce pump maintenance and noise. Small samplers are desirable because of the limited space around glove-box lines and the type most widely used is shown in Fig. 5.

Since the samplers utilize fixed filters and gross alpha detectors, they operate with a background count due to the collection and detection of naturally occurring alpha emitters in the air. This inherent background makes rapid detection of low levels difficult. Another contributing factor which makes rapid detection of low levels difficult is the fact that the alarm trip must be set sufficiently high to minimize inadvertent or spurious alarms; otherwise, persons in the area may become distrustful of and unresponsive to genuine alarms. In spite of the difficulties, these samplers have on occasion detected excessive levels which would have otherwise gone undetected until the following day.

C. Count Room

The task of counting numerous 4- x 9-in. filter papers for alpha activity was difficult during the early years because counting techniques and equipment were in the development stage. The first satisfactory counters were manual scalers with large gas proportional detectors (Fig. 8). Each filter had to be loaded manually and each count was recorded by hand. Operation of the counters required a number of technicians and the results were subject to human error. Replacement of these counters with ones having automatic sample changer and readout capabilities began in 1964.

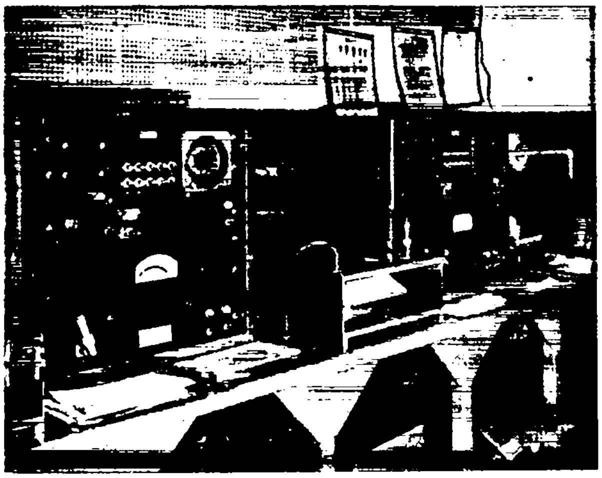

Fig. 8. Early Los Alamos filter counters.

Instrumentation in the central count room now includes two Widebeta II systems, two Nuclear Measurement Corporation Model PC-3T counters, and a scintillation counter assembled at Los Alamos. The Widebeta counters, used for counting routine sample filters, are capable of counting 100 filters per loading and automatically printing identified results on a tele typewriter readout unit (Fig. 9).

Daily precount calibration checks, to determine the counter efficiency, are made with a standardized source. The counting time, approximately 2.7 min, is used so that the total number of counts accumulated during the count period will equal the alpha activity in disintegrations per minute. This eliminates an arithmetic step for the full-time count technician. The counter efficiency is the only factor applied in converting the counting results to activity in disintegrations per minute (d/min).

RESULTS AND RECORDS

Once the filter activity in d/min has been determined, the task of preparing permanent records of the sample must be considered. A logical way is to accumulate the results by room in chronological order. However, experience has shown some advantages in maintaining an additional personnel exposure record for each individual. The following is the sequence used to generate this record: (1) each sample result is identified and converted to a concentration on Form 1 (Fig. 10) which also includes sample location and time, count time, and sampling rate; (2) the data on Form 1 are used to de-

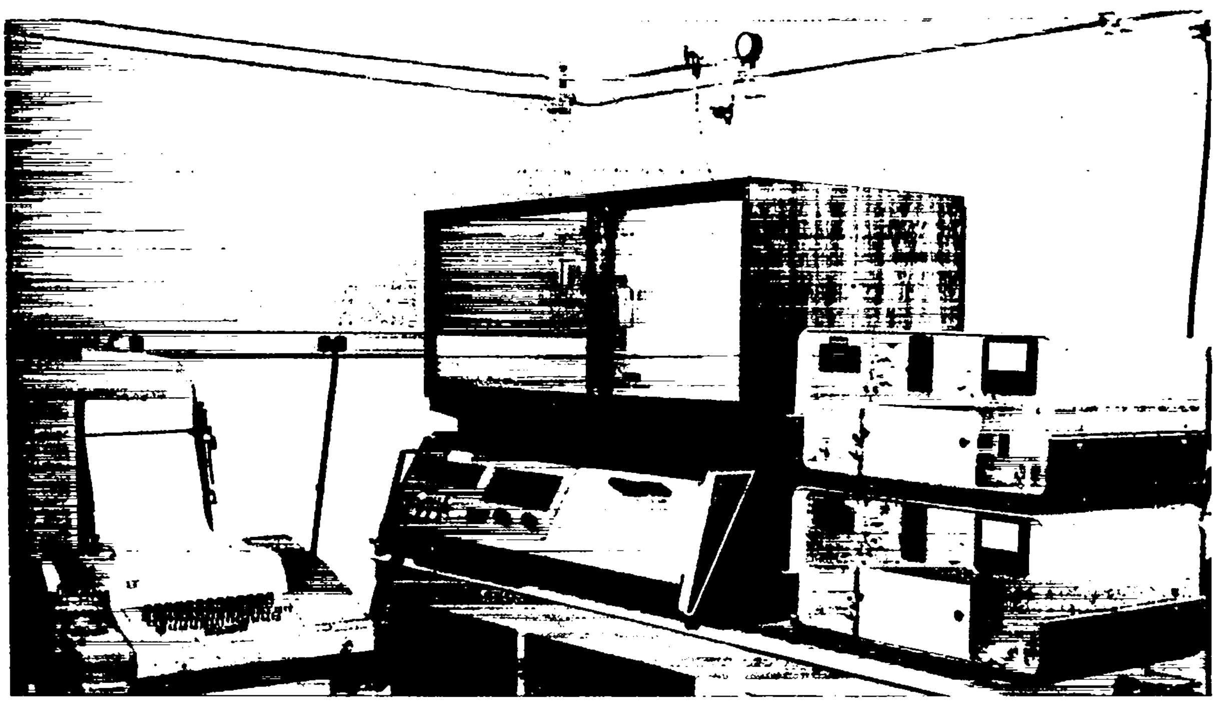

Fig. 9. Present filter counters.

termine an average concentration for each room which is recorded on Form 2 (Fig. 11); and (3) the Health Physics Surveyors use these averages to prepare a Personnel Exposure Record, Form 3 (Fig. 12) for each person assigned to their area.

Forms 1 and 2 are completed by the count room technician and are placed in permanent storage after one year. The Personnel Exposure Records are placed in the individual's Medical Record file at the end of each year. Because air samples are a measure of operation contamination control, supervisors in the operating group are notified immediately of routine sample concentrations in excess of 4 d/min-m^3. These samples are also reported in weekly written reports to the Health Physics Group Leader and the Operating Division Leader.

Samples collected during normal operations seldom measure concentrations over 4 d/min-m^3; however, over the past five years they have averaged 1 d/min-m^3. This average concentration is 25% of the 2×10^{-12} μCi/cc air concentration standard for soluble plutonium and is probably caused by natural occurring alpha emitters remaining on the filter paper after the overnight decay period rather than plutonium.

COSTS

Costs are briefly mentioned for those health physicists who are considering such a program. Estimated initial equipment costs along with manpower and material costs are given in Table I. Manpower and filter paper expenses alone amount to $0.32 per routine sample. Expense items not included are record forms, equipment maintenance, incidental equipment replacement, and record storage.

SUMMARY

The present program for monitoring airborne plutonium in the LASL plutonium facility working environment has evolved from early equipment and techniques into an adequate and practical system. Central sampling systems and automatic filter counters permit sampling at more than 350 fixed locations. Samples collected during normal operations seldom measure concentrations over 4 d/min-m^3; however, over the past five years they have averaged 1 d/min-m^3. This concentration is 25% of the 2×10^{-12} μCi/cc air concentration standard for soluble plutonium. This would be a significant shortcoming in the program if the user wanted to prove that air concentrations or chronic exposure levels were below 1 d/min-m^3.

The general air concentration trend has been downward and experience has shown that the urinary excretion levels do not exceed detection limits for present-day chronic exposures received by workers at the facility. Measurable exposures from airborne plutonium occur only under accidental conditions.

The program is adequate for the routine monitoring of airborne plutonium; however, additional data must be obtained before a true evaluation of health hazards can be attempted.[4,5] Personnel exposure is difficult to determine from the air monitoring results, and techniques directly involving the individual must be relied on for making final exposure evaluations.

ACKNOWLEDGMENTS

The authors are grateful to Julia Emery for typing and arrangement of the final report.

AIRBORNE CONTAMINATION TESTS

AREA DP West

Room 201	1-9-69 TIME			m^3/		DATE COUNT TIME		
LOCATION	BEGIN	END	HRS	min	m^3	d/min	d/min-m^3	REMARKS
1-A	8:00	4:30	8 1/2	.056	28.6	29	1	171.6 M^3
1-B						37	1	
1-C						25	1	
2-A						39	1	Ave. 1
2-B						31	1	
[illegible]						[illegible]	1	[illegible]

Fig. 10. Individual sample record.

AIRBORNE CONTAMINATION TESTS

AREA DP West LOCATION Room 201

TEST	DATE	TOTAL m^3	d/m	d/min-m^3	REMARKS
1	1-2-69	429.0	289	1	Group CMB-11 (alpha Pu)
2	1-3-69	"	198	0	
3	1-4-69	"	229	1	
4	1-5-69	"	70	0	
5	1-6-69	"	327	1	
6					

Fig. 11. Average sample record.

PERSONNEL EXPOSURE RECORD
AIRBORNE ALPHA CONTAMINATION

DP WEST AREA

Name: Doe, John Q
Z-00000

January, 1969 (--) Person not in immediate area

Date	Room No. and Average d/min-m^3					Remarks
January	Room 500	Room 513				
2	0	0				
3	0	0				
4	0	0				
5						

Fig. 12. Personnel exposure record.

TABLE I. ESTIMATED MANPOWER, MATERIAL AND INITIAL EQUIPMENT COSTS.

Manpower	351 Samples per Day
Health Physics Surveyors (5 h/day @ \$7.50/h)	\$0.11/sample
Count Technician (8h/day @ \$7.50/h)	0.17/sample
Filters	
HV-70, 2-1/8-in. diam	0.04/sample
Total	\$0.32/sample
Equipment	Initial Cost
Counting room counters	\$35,000
Continuous air samplers	32,500
Central sampling systems	30,000
Total	\$97,500

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