MASTER

ROCKY FLATS CONTINUOUS AIR MONITOR

by

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RELEASED FOR ANNOUNCEMENT
IN NUCLEAR SCIENCE ABSTRACTS

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CONTRACT AT(29-1)-1106

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Printed in USA. Price \$1. Available from the Clearinghouse for Federal
Scientific and Technical Information, National Bureau of Standards,
U. S. Department of Commerce, Springfield, Virginia 22151

2 November 1966

RFP-815
UC-41 HEALTH
AND SAFETY
TID-4500

USU PRICES

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H.C. \$ 1.00 ; MN. 50.

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A B S T R A C T

A reliable and inexpensive (less than \$400) continuous air monitor has been developed. The air monitor, an alpha scintillation device, continuously monitors air samples collected on 47-mm filter paper. A readout is provided by a transistorized rate meter and an adjustable meter relay. The meter relay actuates an alarm when a preset amount of activity is collected on the filter paper. An outlet plug is provided for a recorder if one is desired.

Based on a Radioactivity Concentration Guide (RCG) of 9 dpm/M³, the continuous air monitor is capable of identifying as little as 1 RCG-day and alarming at this amount. At Rocky Flats the instrument is usually set to alarm at approximately 3 RCG-days above natural background radiation. Numerous instruments are located throughout plutonium-handling areas and employ a warbling alarm as an indication that respiratory protection is required.

INTRODUCTION

When plutonium is handled in gloveboxes one of the most serious radiological hazards is that of airborne plutonium resulting from loss of glovebox integrity. The number and magnitude of personnel exposures from airborne activity is closely related to the time required to detect the airborne activity and to warn personnel in the area of the potential hazard. Experience has demonstrated that airborne plutonium outside of a glovebox can spread quickly to distant parts of a work area. Because many plutonium aerosols are composed largely of very small particles (0.1 to 0.5 micron),^{1,2,3} an airborne hazard can exist for some time before noticeable surface contamination is detected.

The above considerations show the desirability of a system which continuously samples the atmosphere for airborne contamination and warns personnel when excessive amounts of airborne activity are present. Because of the size of the plutonium-handling areas at Rocky Flats (greater than 100,000 sq.ft.), a large number of instruments is necessary to provide complete coverage. Consequently, the cost per unit becomes an important consideration in the development of a continuous air monitoring instrument. The air monitor discussed in this report has been fabricated for Rocky Flats at a cost of about \$400. This cost includes a recorder and an alarm system.

DESCRIPTION OF INSTRUMENT

At Rocky Flats a central vacuum system is used for all routine air sampling. The sampling is performed at a flow rate of 2 cfm using 47-mm Hollingsworth and Vose Type 70 filter paper. The continuous air monitor uses an RCA 6655A photomultiplier tube (2 inches in diameter) with a ZnS phosphor to monitor the filter paper. The tube holder and air collection arrangement are shown in Figure 1.

The ZnS phosphor is deposited on one side of transparent, double coated, pressure sensitive tape. The reverse side is stuck directly to the photomultiplier tube. This type of phosphor is very easily (and inexpensively) changed. This feature is important since the phosphor tends to pick up some contamination whenever highly contaminated air is sampled.

¹Moss, W. D., Hyatt, E. C., and Schulte, H. F., "Particle Size Studies on Plutonium Aerosols," *Health Physics* 5, 212 (June 1961).

²Andersen, B. V., "Particle Size Distribution Found in Air at Hanford Plutonium Fabrication Facilities," USAEC Report HW-SA-3197 (September 1963).

³Kirchner, R. A., "A Plutonium Particle Size Study in Production Areas at Rocky Flats," USAEC Report RFP-671 (November 1965).

Figure 1. TUBE HOLDER AND AIR COLLECTION ARRANGEMENT

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The pulses from the photomultiplier tube are amplified by two stages of transistor amplification. The second stage triggers a monostable multivibrator, which in turn drives an integrating meter relay. A portion of the current which drives the meter relay can also be used to drive a recorder. A trimmer potentiometer determines the portion of current drawn through the meter relay and recorder. This potentiometer is used to calibrate the instrument. The meter relay has both upper and lower set points which can be easily varied. The upper set point is used for an alarm and the lower set point is available to indicate possible circuit malfunction since background count should keep the meter above zero except immediately following filter replacement. An output for a recorder is available. The complete circuit is shown in Figure 2.

Any type of alarm can be used as long as the alarm circuit does not draw more than 10 milliamperes through the contacts of the meter relay. The circuit shown in Figure 2 does not provide power to the alarm but this could easily be built in if all alarms had uniform voltage and power requirements.

Figure 2. SCHEMATIC OF CONTINUOUS AIR MONITOR

MATERIAL LIST

Q ₁ - 2N863	C ₁₁ - 0.01 μ f/50 v	R ₂₀ - 8.2 k
Q ₂ - 2N706	C ₁₂ - 1 μ f	R ₂₁ - 4.7 k
Q ₃ , Q ₄ - 2N1306	C ₁₃ - 0.001 μ f/2 kv	R ₂₂ - 47 k
Q ₅ - 2N3646	C ₁₄ - 50 μ f/15 v	R ₂₃ - 8.2 k
Q ₆ - 2N414	C ₁₅ - 150 μ f/15 v	R ₂₄ - 33 k
D ₁ - 1N2071	C ₁₆ , C ₁₇ - 0.01 μ f/200 v	R ₂₅ - 1 k
D ₂ - 1N1519	T ₁ - Triad F-90X	R ₂₆ - 50 k (Miniature) 1/2 w
D ₃ - 1N3283	T ₂ - Microtran M8050	R ₂₇ - 150/2 w $\pm$ 5%
D ₄ - 1N2071	J ₁ - 4-Pin Jones Female	R ₂₈ - 10 k (Miniature) 1/2 w
D ₅ - 1N1523	J ₂ - 2-Pin Cannon Male	R ₂₉ - $\approx$ 5 k (Select for 500-1500 v range)
C ₁ , C ₂ - 470 pf/300 v	R ₁ - 6.8 M	R ₃₀ - 270
C ₃ - 470 pf/1 kv	R ₂ - 1 M	R ₃₁ - 200/2 w $\pm$ 10%
C ₄ - 500 pf/500 v	R ₃ -R ₁₃ - 4.7 M	R ₃₂ - 820
C ₅ - 0.001 μ f	R ₁₄ - 560 k	M - Simpson Mod. 29XA 0-100 μ a d.c.
C ₆ - 0.47 μ f/150 v	R ₁₅ - 22 k	PM - Photomultiplier Tube 6655A
C ₇ - 150 μ f	R ₁₆ - 1 M	F ₁ = 1/4 amp
C ₈ - 3000 μ f/15 v	R ₁₇ - 2 k	
C ₉ - 15 μ f/15 v	R ₁₈ - 22 k	
C ₁₀ - 150 μ f	R ₁₉ - 100	

NOTE - All capacitors 6 v rating unless noted.
All resistors 1/4 w 5% tol. unless noted.

A circuit for a warbling alarm is shown in Figure 3. The alarm circuit is energized by a low-current relay actuated by the closing of the meter relay contacts. The alarm consists of a phase shift oscillator in combination with an astable multivibrator to alternate the tone between two distinct frequencies. The output stage of the alarm drives a 4-inch speaker. The tone of the alarm varies from approximately 1600 to 1800 hertz at a rate of about 2 hertz.

Figure 4 shows the complete unit with recorder and warbling alarm.

number is actually quite conservative because the Maximum Permissible Concentration for insoluble plutonium in air, $(MPC)_a$, is 88 dpm/M³ (40-hr. week).⁴ Airborne plutonium at Rocky Flats can, for practical purposes, be considered 100 percent insoluble. Using the RCG of 9 dpm/M³, an RCG-day can be defined as the amount of material which a person is permitted to breathe in 1 day. Since the alarm meter on the continuous air monitor indicates the accumulated amount of activity collected on the filter, the RCG-day can be related to a deflection on the meter. It is, therefore, convenient to discuss alarm levels and relative hazards in terms of RCG-days.

USE AND INTERPRETATION OF RESULTS

The Radioactivity Concentration Guide (RCG) used for airborne plutonium at Rocky Flats is 9 dpm/M³. This

⁴Report of ICRP Committee II on Permissible Dose for Internal Radiation (1959), *Health Physics* 3, 1 (June 1960).

Figure 3. SCHEMATIC OF WARBLING ALARM

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Figure 4. CONTINUOUS AIR MONITOR

As a point of reference: 10 RCG-days represents slightly less than one-thousandth of the permissible lung burden. (This assumes 50 percent of the inhaled aerosol is retained in the lung.)

When very low-level airborne activity needs to be measured, the interference caused by atmospheric background can be very difficult to overcome. The first prototypes of the continuous air monitor were run continuously in different areas to determine the magnitude and variability of atmospheric background. Very rarely was the background variation over a 1 RCG-day. Usually the background was very

constant at a meter reading corresponding to between 1 and 2 RCG-days. Consequently, no system for background compensation was considered necessary for the Rocky Flats instrument. When large variations did occur they were on the high side, indicating an airborne plutonium hazard when, in fact, none existed. It was noted that the background rose to approximately 90 percent of its equilibrium value within 15 minutes after the instrument was started or a new filter inserted.

The alarm level setting of the instrument varies somewhat with location but is usually about 3 RCG-days above background. Three RCG-days represents about 50 percent of fullscale meter deflection. Figure 5 shows the recording chart from an instrument exposed to sources representing from 1 to 5 RCG-days.

The alarm is not used as a signal for building or area evacuation but rather as an indication that an airborne hazard exists and respirators should be worn. All personnel within hearing range of the alarm remain in respirators until Health Physics personnel investigate the area.

The distribution of the air monitors in production areas is dependent on airflow patterns within the areas. They are located in a manner designed to give the fastest possible indication of an airborne hazard. Each instrument has its own alarm(s). The audible range of the alarms is sufficient to give an overlapping coverage of one instrument with another. Using this alarm system and a relatively large number of instruments, the respirator areas are limited quite closely to the areas of actual high airborne activity.

Only about 20 percent of the air monitors in use have a recorder attached. This is because the recorders are not used for routine records but rather to provide a time base for determination of concentration levels in case of a large-scale release of airborne plutonium. The filter papers on the continuous air monitors are changed daily or whenever they are noticeably contaminated. The sampling heads immediately beside the air monitors are used as routine sampling stations and their results are recorded as a permanent record.

Figure 5. RECORDING CHART