RFP-2435

COMPUTER CONTROLLED
DIRECT AIR SAMPLE COUNTING

by
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November, 1975

RFP# 2435

Rockwell International, Atomics International Division, operates the Rocky Flats Plant as a Prime Contractor to the U. S. Energy Research & Development Administration under contract Number E(29-2)3533.

240
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ABSTRACT

At Rocky Flats approximately 1000 effluent and process area air samples are collected daily. These samples are then transferred to a central facility and direct counted for gross alpha concentrations. These concentrations are determined by utilizing a 100 detector system with a mini-computer. The computer controls the count cycle and performs data manipulations. The results are stored on magnetic tape. This system is designed and programmed in such a manner that it can be operated by semi-skilled personnel with a minimum of training.

I INTRODUCTION

Prior to 1974 all gross alpha counting was performed in various production facilities at Rocky Flats. Several problems, such as contamination incidents and electrical power fluctuations associated with production facilities, indicated a need for a facility removed from manufacturing buildings. Funds were requested and approved to add a wing to the existing Health Physics Lab Building and to provide for new instrumentation to replace outdated equipment. A 100 detector gross alpha counter was designed at Rocky Flats and built by an outside firm. This paper describes that equipment and its operating theory and procedures.

II EQUIPMENT

Electrical power is supplied thru a motor-generator set that provides stable voltage. The M-G set is re-started manually after power outages to prevent damage to delicate electronics.

The detectors are photo-multiplier tubes with zinc-sulfide phosphors. Twenty light tight bins with 5 detectors each are mounted in 2 cabinets. Each bin has a drawer which has 5 sample holders. When the drawer is closed the sample holder is raised to approximately one-half inch of the detector. This configuration minimizes background contribution from surface plutonium contamination on the drawer and bin surfaces.

The events seen by the detectors are recorded on blind scalers. These scalers are part of the CAMAC interface between the detectors and computer. CAMAC is a data way by which modules, computers and computer peripherals can communicate.

After the count cycle , the mini-computer scans the CAMAC, receives the data and performs certain calculations.

The computer is programmed in such a manner that data entry and count mode selection can be performed easily by semi-skilled personnel. For example, after the count mode has been selected,

the computer is programmed to ask for the additional information required to perform the assignment. The computer, programmed with Assembly Language, has a 16K core and is used almost to capacity.

The processor utilizes a 64K fixed head disk to store such data as background, sample location codes and other pertinent information. All disk files can be easily updated thru the printer by utilizing one of many options incorporated in the software.

Data is printed out on local printers in the count lab and on remote devices located in the area Radiation Monitoring offices. The remote printers are tied to the computer thru asynchronous interfaces via dedicated telephone lines.

After the results are printed out, they are stored on magnetic tape for permanent retention. This data can also be updated by the same method as the disk. Future plans call for developing software for compiling summary reports.

Spare equipment was acquired so that downtime will be minimized. Since we collect approximately 1000 samples per day, a backlog could rapidly accumulate.

of the spare equipment includes:

- 1) a minicomputer
- 2) a high-speed paper-tape reader/punch
- 3) CAMAC blind scalars
- 4) a CAMAC power supply
- 5) a local printer

These spare components are also utilized in performing system maintenance. The CAMAC equipment and detectors are maintained internally. A maintenance contract with the local vendor provides for on-call and routine preventative maintenance to the computer and associated equipment.

III SAMPLE COLLECTION

During the sampling period, while transporting and during counting, most filter media are contained in a brass ring. This ring prevents damage to the media, facilitates handling of large volumes of samples and properly orients the filter paper to the detector while being counted.

The samples are collected in a prescribed order, loaded in a metal tube, placed in a shipping container and transported to the count lab. A rubber stopper is placed inside the tube prior to transport to prevent damage or sample loss during shipping. These samples are collected and transported by Radiation Monitoring personnel to assure proper handling.

IV INSTRUMENT CALIBRATION

The instrument is calibrated daily prior to any sample counting. The calibration is performed utilizing 100 electroplated ^{239}Pu alpha sources traceable to the National Bureau of Standards. If a particular detector is out of tolerance, the source to detector distance is mechanically adjusted to bring the instrument within calibration limits. The acceptable calibration range is $30 \pm 1\%$ of 4π geometry. If a detector cannot be adjusted properly, it is flagged out by the computer and not used.

The background is also checked daily. A 60 minute run with clean filter papers in place is performed, and the resulting counts/minute are stored on the disk for subsequent use. The control level is 0.5 counts/minute.

V SAMPLE COUNTING

A. Work Area Or Occupational Air Samples

The samples are loaded into the counter from the sample tubes. They are loaded in the same order in which they are collected, therefore a particular detector is dedicated to a particular sample each time the sample is counted. To allow for decay of short-lived activity, the samples are counted 24 hours after collection.

The following is an example of the data required to count work area samples. This data is entered thru the local printer.

- 1) Enter Run Type - XX - The computer returns to this statement after completion of each operation. The work area samples are identified by the numbers 1 thru 19. These numbers further identify the building, the RCG (Radioactive Concentration Guide) Basis, sample location code, room number and a code identifying departmental responsibility.
- 2) Enter Sampling Period - Min - From this information the sample volume is calculated. All occupational samples are collected at a sampling rate of 50 liters per minute, $\therefore$ a typical volume is
$$\frac{50 \text{ l/min (1440 min/day)}}{10^3 \text{ l/M}^3} = 72 \text{ M}^3$$
- 3) Enter Data Sample on MMDDYY -
For November 5, 1975, the date would be entered as 110575 .
- 4) Enter Date Sample Off MMDDYY -

5) Is a 1 Minute Count Desired -

If a quick check is desired, the technician enters YES. When NO is entered, the computer is automatically instructed to perform a 10 minute count.

6) Is Data Entered OK -

If an error has been made in data entry, the processor is answered NO. The CPU will then return to Step 1. If YES is returned, the appropriate heading (Figure 1) is typed out and the samples counted.

At the end of the count cycle the results are printed out locally and at the appropriate remote terminal (Figure 1).

The results printed consist of those samples greater than 25% of the RCG, the sample location code, the room number and the department code. All results are then stored on magnetic tape.

FIGURE 1

RADIATION MONITORING AIR SAMPLE SYSTEM

DATE= 110575
TIME= 1221
COUNT TIME= 10MIN
RUN TYPE= 1

ANALYSIS

ROOM SAMPLES

771&774

100 % RCG= 4.400 D-M-M3

COUNT GEOM= 30 %

BG. CONTROL = < 1 C-M

FILTER MED. = 70 %

SAMPLE ON 110375
SAMPLE OFF 110475
SAMPLE VOL 72.000M3

CHANNEL NO.	RESULTS % RCG		
4	175.761	A-4	114-CO
5	38.178	A-5	114-CO
7	35.623	A-7	114-CO
16	46.470	A-16	114-CO
17	61.326	A-17	249-UT
21	38.629	A-21	249-UT
24	25.728	A-24	249-UT
25	30.863	A-25	249-UT
57	76.006	B-29	149-CO

E N D 1038

The calculations performed are:

$$(1) \frac{(\text{gross counts/time}) - \text{bkg}}{(30\% \text{ geometry}) (\text{filter efficiency})} = \text{d/m}$$

$$(2) \frac{(\text{d/m})/\text{volume} (100)}{\text{RCG Basis}} = \% \text{ RCG}$$

No consideration is given to discounting the short-lived activity by the calculations.

B. Gaseous Effluent Samples

The effluent samples are loaded into the counter in the same manner as the work area samples. They are counted twice with a decay interval between the first and second count. By waiting a minimum of 4 hours after collection prior to the first count, the activity from radon decay products becomes negligible. These data are utilized to calculate the amount of short-lived activity contributed by the thoron daughters¹.

As the results of the first count are net counts/minute, little data need be entered. The results of the first count are stored on the disk awaiting completion of the second count. The data entered for the second count is as follows.

¹Determination of Particulate Air-Borne Long-Lived Activity;
George Koval; Clinton Laboratories, Oak Ridge, Tennessee.

1) Enter Run Type -

The appropriate run type for effluent samples is either 20 or 21. This identifies the type of samples and references a particular detector with a particular sample.

2) Enter First or Second Count -

3) Enter Delta T Between Counts - Min -

The time between the count is used in calculating the net counts/minute long-lived activity. Normally 24 hours (1440 minutes) is the delta T.

4) Enter Sampling Period - Min -

This data is used to calculate the sample volume. All effluent stacks at Rocky Flats are sampled isokinetically at 2 cfm.

5) Enter Date Sample On MMDDYY -

6) Enter Date Sample OFF MMDDYY -

7) Enter Count Time - Min -

Effluent samples are normally counted for 60 minutes.

8) Is Data Entered OK -

The heading is then printed out (Figure 2) and the samples are counted. At the end of the count cycle all the results are printed locally and remotely. The results include the first counts/minute, second counts/minute, disintegrations/minute/cubic meter, the sample location code and the standard deviation.

The calculations required to compute the $d/m/M^3$ are:

$$(1) \quad C/M_{LL} = \frac{C_2 - C_1 e^{-0.0655 \Delta t}}{1 - e^{-0.0655 \Delta t}}$$

C/M_{LL} = counts/minute long lived

C_1 = 1st net counts/minute

C_2 = 2nd net counts/minute

Δt = time between 1st and 2nd count in hours

$$(2) \quad d/m/M^3 = \frac{C/M_{LL}}{\frac{(30\% \text{ geometry})(\text{filter efficiency})}{\text{Sample Volume}}}$$

FIGURE 2

RADIATION MONITORING AIR SAMPLE SYSTEM

DATE= 110775
TIME= 742
COUNT TIME= 60MIN
RUN TYPE= 20

A N A L Y S I S

EFFLUENT SAMPLES
COUNT GEOM= 30 %
BG. CONTROL = < 1 C-M
FILTER MED. = 70 %

SAMPLE ON 110375
SAMPLE OFF 110575
SAMPLE VOL 163.008M3

CHANNEL NO.	COUNT 1	COUNT 2	RESULTS D-M-M3	THREE SIGMA
1	0.567	0.017	0.000 101-1	0.011
2	0.767	0.217	0.002 -2	0.008
3	1.150	0.317	0.003 102-3	0.009
4	1.283	0.183	0.000 -4	0.008
5	0.000	0.000	0.000 105-5	0.008
6	0.050	0.000	0.000 -6	0.009
7	0.150	0.017	0.000 -7	0.007
8	0.033	0.000	0.000 106-8	0.007
9	0.050	0.067	0.002 -9	0.005
10	0.033	0.000	0.000 107-10	0.006
11	0.000	0.000	0.000 -11	0.028
12	0.167	0.000	0.000 -12	0.015
13	0.033	0.000	0.000 108-13	0.007
14	0.000	0.000	0.000 -14	0.043
15	0.100	0.000	0.000 -15	0.021
16	0.050	0.000	0.000 782-1	0.005
17	0.183	0.033	0.000 -2	0.005
18	0.083	0.000	0.000 -3	0.007
19	0.000	0.000	0.000 729-1	0.020
20	0.183	0.133	0.004 -2	0.007
21	0.317	0.100	0.001 201-1	0.010
22	0.317	0.000	0.000 -2	0.006
23	1.450	0.433	0.005 204-1	0.012
24	1.483	0.183	0.000 -2	0.009
25	1.900	0.333	0.000 -3	0.011
28	0.067	0.000	0.000 206-1	0.007
29	0.133	0.267	0.009 -2	0.009
30	0.100	0.000	0.000 250-1	0.007
31	0.000	0.000	0.000 -2	0.010
32	0.167	0.000	0.000 -3	0.007
33	0.050	0.017	0.000 -4	0.005
34	0.117	0.000	0.000 -5	0.006
35	0.117	0.000	0.000 251-1	0.009
36	0.267	0.050	0.000 -2	0.013

There are several calculations to determine the standard deviation² and too lengthy to describe in detail here.

They involve the following:

- 1) backgrounds, 1st and 2nd count
- 2) 1st net counts/minute
- 3) 2nd net counts/minute
- 4) counts/minute long-lived alpha
- 5) counting geometry
- 6) filter efficiency
- 7) sample volume

Three times the standard deviation is utilized to describe the limits of error and to assist in plotting trends of a particular air-cleaning system.

VI CONCLUSIONS

The procedures and equipment described here are utilized in rapid and accurately counting large quantities of air samples and retaining that data for future use. Gross alpha determinations may not be as accurate as chemical analysis for a specific isotope, but is more rapid in giving the operational Health Physicist immediate answers from which actions may be taken. Future applications

²Precision of Measurements for Monitoring Radioactivity of Effluent from Ducts and Stacks, RFP 2422; Dr. Judith Selvidge, Consultant; Atomics International Division, Rocky Flats Plant, Rockwell International.

include utilization of solid state detection to allow for automatic subtraction of short-lived activity, and the addition of light-emitting diode scalers to be used to rapidly detect equipment failure and as backup in case of failure of vital components.