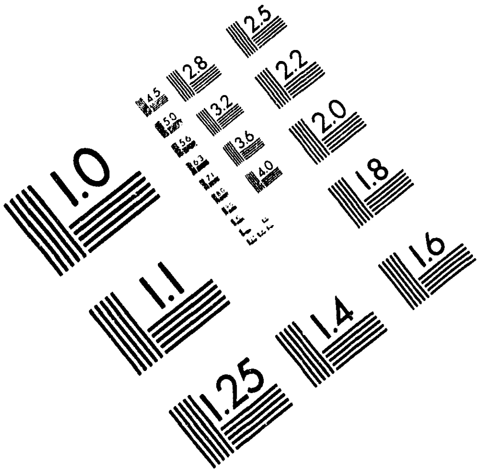

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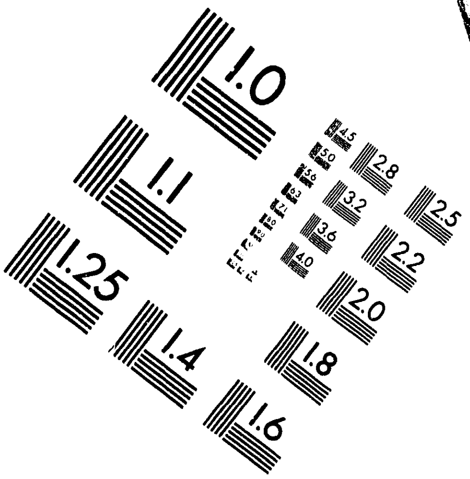

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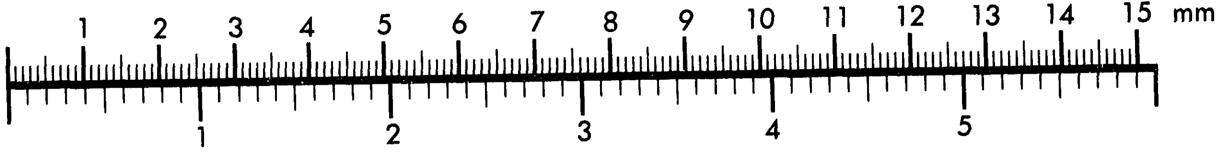

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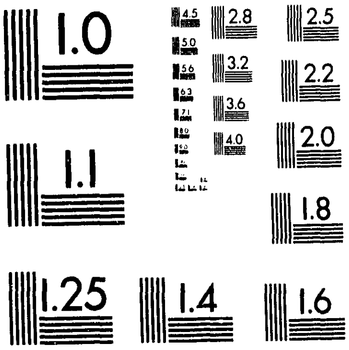

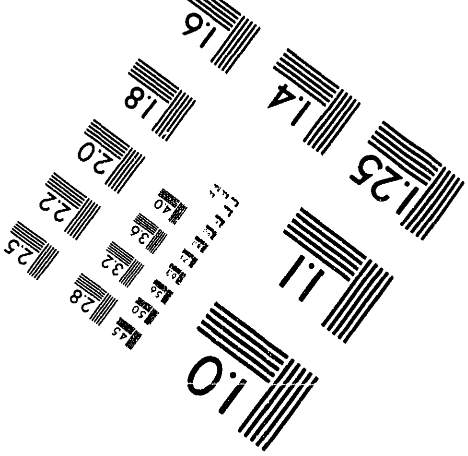

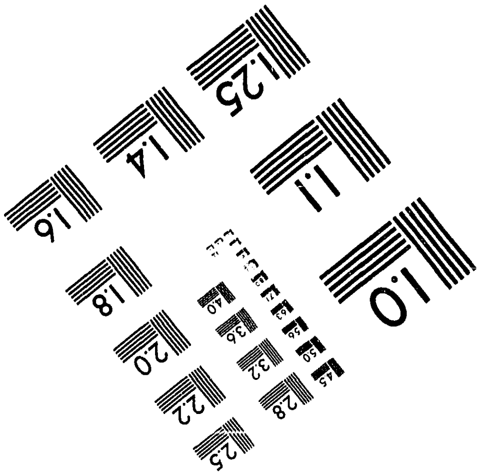

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Title: CONTINUOUS AIR MONITOR CORRELATION TO FIXED AIR SAMPLE DATA AT LOS ALAMOS NATIONAL LABORATORY

Author(s): J. J. Whicker

Submitted to: DOE/Radiation Protection Workshop
Las Vegas, NV
April 13-15, 1993

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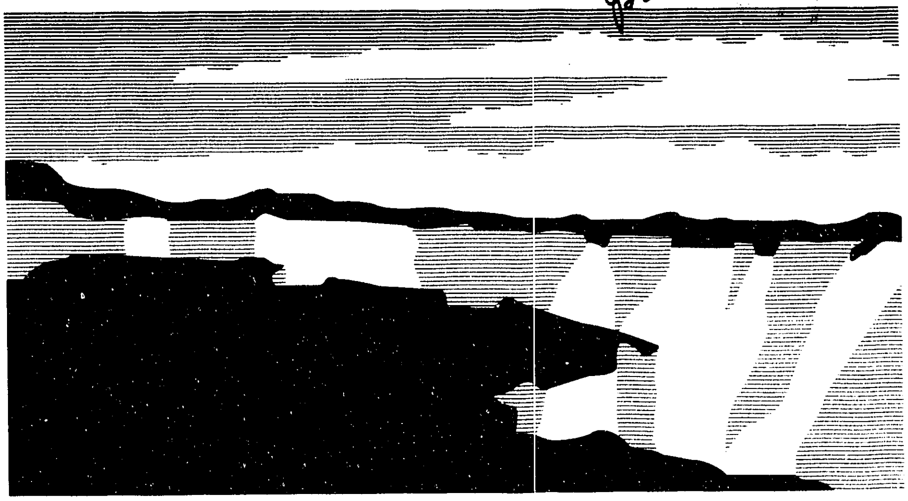


Los Alamos
NATIONAL LABORATORY

Title: Continuous Air Monitor Correlation to Fixed Air Sample Data
at Los Alamos National Laboratory
Author: Jeff Whicker
Los Alamos National Laboratory

Abstract

Continuous air monitoring instruments (CAMs) deployed in laboratories in the TA-55 plutonium facility at Los Alamos National Laboratory (LANL) alarmed less than 33 percent of the time when fixed air sample measurements in the same laboratory showed integrated concentrations exceeding 500 DAC-hrs. The purpose of this study was to explore effects of non-instrument variables on alarm sensitivities for properly working CAMs. Non-instrument variables include air flow patterns, particle size of released material, and the energy of the release. Dilution Factors (DFs) for 21 airborne releases in various rooms and of different magnitudes were calculated and compared. The median DF for releases where the CAM alarmed was 13.1 while the median DF for releases where the CAM did not alarm was 179. Particle sizes ranged considerably with many particles larger than 10 μm. The cause of the release was found to be important in predicting if a CAM would alarm with releases from bagouts resulting in the greatest percentage of CAM alarms. The results of this study suggest that a two-component strategy for CAM placement at LANL be utilized. The first component would require CAMs at exhaust points in the rooms to provide for reliable detection for random release locations. The second component would require placing CAMs at locations where releases have historically been seen. Finally, improvements in CAM instrumentation is needed.

Introduction

In November of 1992, Defense Programs (DP) of the Department of Energy (DOE) conducted an appraisal of the performance of the continuous air monitors (CAMs) used at the main plutonium facility at Los Alamos National Laboratory (LANL). CAMs provide real-time monitoring of room air for airborne releases of radioactive material, in this case, primarily isotopes of plutonium (Pu). The appraisal mainly focused on the CAMs availability to detect releases and a probabilistic risk assessment (PRA) was performed to estimate the risk to workers from CAM unavailability. Specifically, the PRA was used to determine the likelihood of a worker intake where a CAM malfunction was a contributing factor.

Secondarily, the appraisal team looked at the CAM's alarm sensitivity to airborne releases. The alarm sensitivity was defined as the ability of a properly working CAM to alarm given an airborne release of Pu. It was found that on numerous occasions integrated air concentration measurements from the fixed air samplers (FASs) were quite high (i.e. greater 500 DAC-hours) and the properly working CAMs did not alarm (Table 1). Similar findings were also reported for other DOE weapons complex sites such as Rocky Flats. While superficially this appears disturbing, it was the conclusion of the appraisal team that the CAMs provide an important but small role in protecting workers from internal depositions and that other components of the radiation protection program (i.e. training, engineered containment, self-monitoring

Table 1

PERCENT OF EVENTS WITH A CAM ALARM FOR VARIOUS DAC-HR MEASUREMENTS WITHIN THE SAME ROOM

DAC-HR	% OF EVENTS W/ALARM
50 - 100	14
100 - 250	20
250 - 500	18
> 500	33

Data provided by Tom Crites (LLNL)

etc.) were more important in intake prevention than CAMs (Augmented Evaluation Team: Report on Alpha Continuous Air Monitors - Draft March, 1993). However, in light of the appraisal team's data, it is important that we improve our understanding of the variables that affect CAM alarm sensitivity. This information can then be used to improve our CAM program. This study focused on the effects of several important variables that can affect the alarm sensitivity of properly working CAMs.

There are two general factors that contribute to the ability of the CAM to alarm given an airborne release: 1) instrument related factors, and 2) non-instrument related factors. Assuming that some fraction of the released radioactive particles gets to the CAM location, instrument related factors include the transport of the particles of various sizes through the intake lines internal to the CAM, deposition on the membrane filter allowing counting by the CAM's detector, and the CAM's ability to distinguish the Pu radioactivity from the Rn progeny background activity. McFarland et al. (1992) provided a thorough analysis of the effects of various instrument related factors on alarm sensitivity. Non-instrument factors include the transport of the radioactive particles through the air from the release site to the CAM.

There are 3 non-instrument variables that can contribute to the ability of a CAM to detect an airborne release: 1) airflow patterns between the release location and the CAM, 2) the size of the particles can be an important variable in the probability that the particle will get to the CAM, and 3) release kinetics (energetic verses passive). It should be noted that these three variables are not always independent of each other. This lack of independence requires that all available information about a release be considered when predicting if a CAM will alarm.

AIRFLOW PATTERNS

To provide for optimal protection of workers, ideally the CAM should be located immediately downwind of the release point. However, studies of releases at the LANL plutonium facility have shown that the release locations are often not predictable (McAtee, 1990) which presents difficulties when trying to optimally locate CAMs. The current placement strategy relies heavily on placing the CAMs at the exhaust register within each room. This strategy provided for the most reliable detection given that the release locations are often unpredictable.

In addition, predicting the path and velocity of airborne particles within a room is very complicated. Figure 1 shows the general airflow pattern within each laboratory. Prior studies at Los Alamos have explored the advantages and disadvantages of a number of techniques to determine the gross airflow patterns in a room (Pickering et al. 1987). Also, computer modeling of Pu aerosols in Pu processing rooms has been fairly successful (Fairchild et al., 1991), but more work needs to be done in this area.

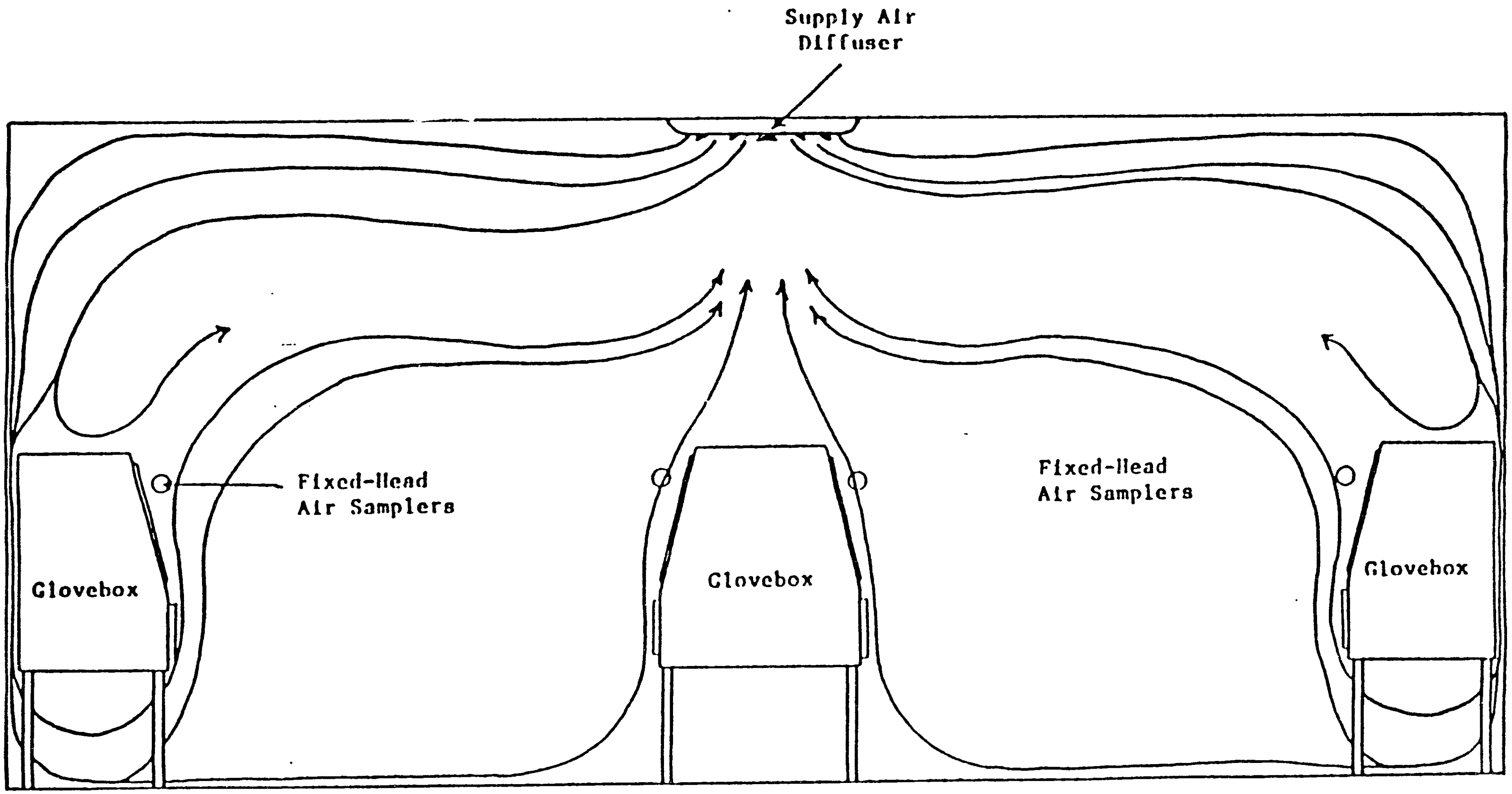
PARTICLE SIZES

The size of a particle can also have an effect on the fate of airborne particles. While the primary variable in determining the

Figure 1.

TYPICAL LABORATORY AIRFLOW PATTERN

AT TA-55/PF-4



Los Alamos

path of smaller particles (i.e. with aerodynamic diameters less than 10 μm) is the airflow pattern, gravitational settling should not be completely ignored as it may have some affect on particles getting to the CAM. For example, one complete room air exchange occurs approximately every 8 minutes in the laboratories. A Pu particle with an aerodynamic diameter of 10 μm will fall up to 1.5 m during this time if no other forces act upon it other than gravity. In addition, the terminal settling velocity increases with the square of the diameter of the particle; therefore, particles greater than 10 μm settle much faster. Finally, if the path of the particle to the CAM is tortuous with lots of piping, wiring, or people to navigate, the larger particles can preferentially deposit on these surfaces through inertial mechanisms and may not get to the CAM.

RELEASE KINETICS

It is reasonable to suggest that energetic releases would expel more radioactive material and that the material would become more dispersed into the room than would passive releases. Consequently, the kinetics of a given release could play an important role in determining if a CAM would alarm. There are many different release types that can occur in Pu facilities. They can range in release energy from passive (i.e. a pin hole in a glovebox glove) to very energetic (i.e. a high pressure releases). Whicker et. al. (1990) provided some evidence that the energy of the release can also affect the size of the particle being released with vigorous releases causing larger particles to become airborne if available.

AIR SAMPLING/MONITORING PROGRAM IN TA-55 AT LANL

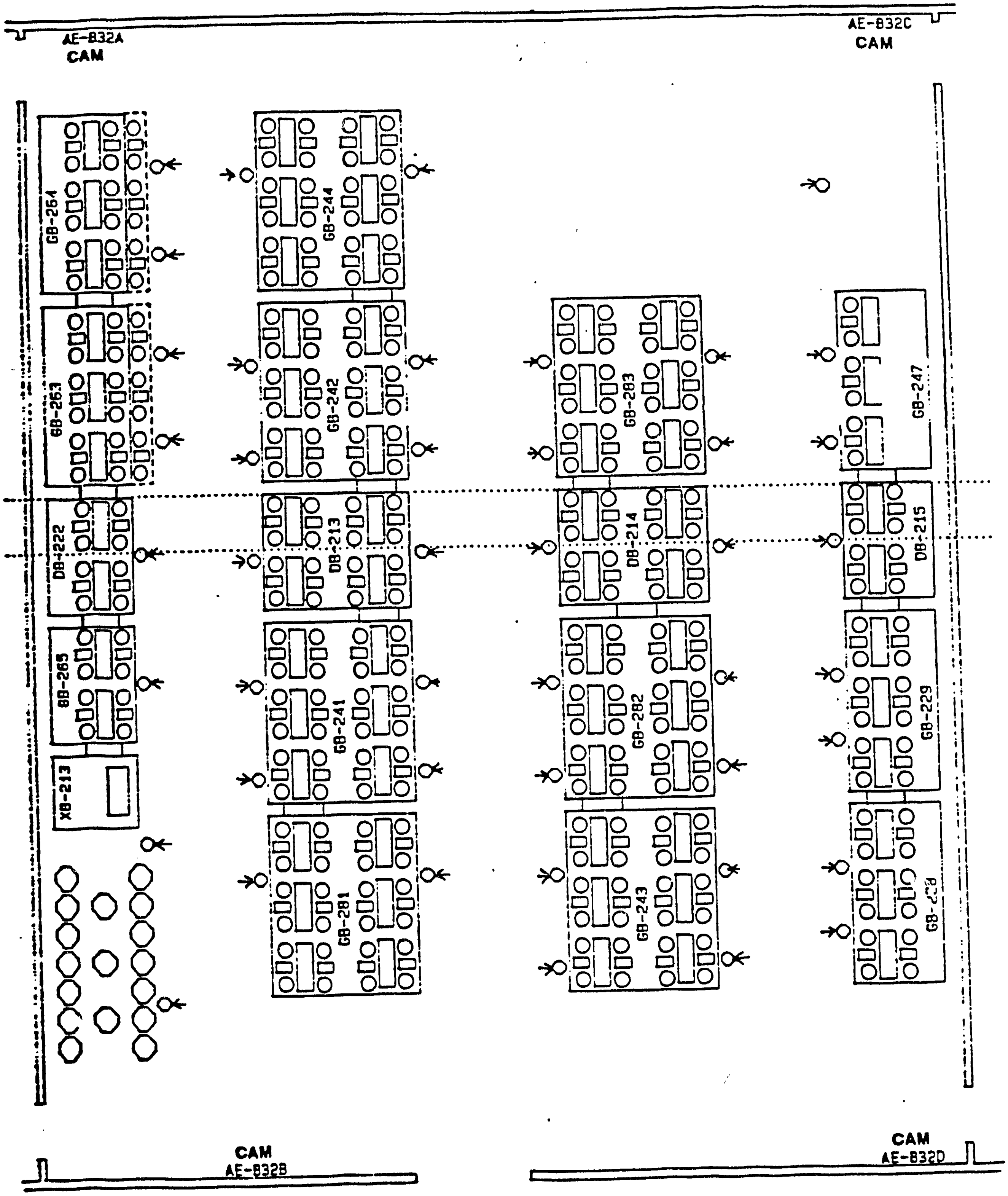
Figure 2 shows the typical layout of FASs and CAMs in each laboratory. The arrows in Figure 2 represent the locations of the FASs while the CAMs are shown in the corners of the room. The FASs are located along the glovebox lines, at every other work station, and approximately 6.5 feet above the floor. The purpose of the FASs are to retrospectively sample room air to ensure containment at low levels. The CAMs are located at each exhaust point within the laboratories; however, portable CAMs are used for some situations. The purpose of the CAMs is to provide for real-time monitoring of the room air and alarm if necessary. There are over 1000 FASs and 190 CAMs within the laboratories.

Methods

To establish differences in releases that did or did not result in a CAM alarm, several variables were explored. These variables include dilution within the room during the release, particle sizes, and causes of the release. It was recognized that these parameters are not necessarily independent of each other. This co-dependence makes for difficult interpretation of the data from each release. Despite these co-dependencies, valuable information can be gained by establishing general patterns.

Figure 2.

Typical layout of laboratory. Arrows designate FASs and the CAMs are shown in the room corners.



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Records of all past radiological incidents are documented and stored in a database. For each incident, the Radiological Control Technicians (RCTs) generated a report which included information on the cause of release, the location of the release, the contamination levels, the nose swipe results, and both FAS and CAM results. Data from these reports from the years 1990 and 1991 were analyzed.

To quantify room dilution of the airborne contamination, a dilution factor (DF) was calculated. The DF was calculated as the highest measured FAS result divided by the lowest positive FAS measurement.

$$DF = \frac{\text{Highest Concentration}}{\text{Lowest Concentration (>NDA)}} \qquad \text{(eqn. 1)}$$

The DFs were then categorized by whether or not a CAM alarmed during the release. The median DFs in each alarm status category were then compared. The medians were used for comparisons because each of the DF distribution populations were skewed.

Particle size distributions were measured using an Anderson Cascade Impactor for several release conditions. The calibrated cascade impactor was placed in the same room as the release and the Pu particles were separated by size and collected on glass fiber filters placed at each stage. These filters were used to minimized particle rebound and for ease of counting. The filters were counted and the Activity Median Aerodynamic Diameters (AMADs) were calculated. Percents of the particles with aerodynamic diameters greater than 10 μm were also determined as 10 μm is considered the cut-off size for respirable particles.

The causes of the releases were also grouped by whether or not a CAM alarmed during the release and were then compared against each other. Additionally, nose swipe data was analyzed to determine which causes of releases most often resulted in positive nose swipes.

Results and Discussion

Table 2 shows the median DF, the DF ranges, and the number of FAS results that showed no detectable activity (NDA) for 21 spills in each CAM alarm category. The median DF for releases where the CAM did not alarm was 179 while only 13.1 in cases with a CAM alarm. The difference between these median DFs suggest that in many cases, the radioactive particles were not getting to the CAM in significant quantities to alarm the CAM. The wide ranges of DFs show that several variables contribute to the ability of a CAM to alarm given a release. For instance, in the case where the DF was 560 and the CAM alarmed, the release occurred in the corner of the largest room in PF-4. By the time the contaminates spread across the room, the released material had dispersed. In the case of the DF of 2.5 with no CAM alarm, the lack of an alarm was due to inappropriate placement of the CAM. Figure 3 shows a 3-dimensional plot showing air concentration level curves for 1 spill and shows the large dilution within the room. The X and Y axes correspond to

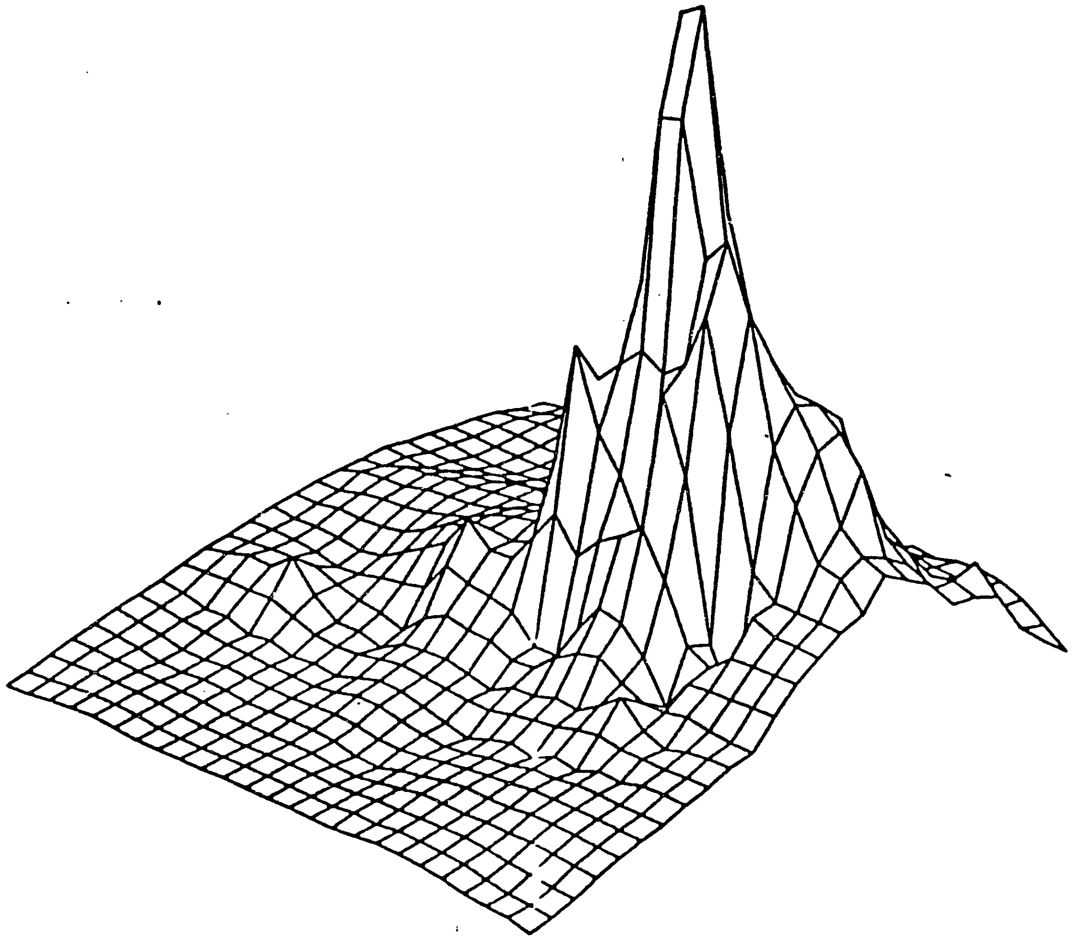
Table 2

DILUTION FACTOR SUMMARY STATISTICS FOR SPILLS:

	CAM ALARM	NO CAM ALARM
MEDIAN DF	13.1	179
# SAMPLERS NDA	3	1
DF RANGE	3.5 - 560	2.5 - 1205

Figure 3.

Three-dimensional plot of air concentrations measured for a release inside a room.
The X and Y axes represent X-Y coordinates of the FASs and the Z axis represents relative air concentrations.



the X and Y coordinates within the room, and the Z axis corresponds to the measured relative air concentrations within the room.

The number of samples that had activities <NDA were very few because the sensitivity of FAS samples were so low. From this data it was difficult to determine differences in the number of FAS results <NDA between CAM alarming releases and no alarm releases. The fact that few FAS results were <NDA is important as the placement and number of CAMs needed to alarm in a room is a function of the sensitivity of the CAM. For example, in almost every case, if the CAM was as sensitive as the FAS counting systems, only 1 CAM per room would be required and the placement of the CAM would be irrelevant.

Table 3 shows that packing/unpacking operations, bagouts, and equipment failures resulted in CAM alarms most often by percentage of releases. Perhaps this can be explained by the fact that these releases are often from pressurized containment systems and when they fail the radioactive material is vigorously expelled into the air. Conversely, glove failures, while being the most common release cause, rarely result in a CAM alarm. I suspect glove failures are usually more passive releases and the contamination is more local. While passive releases such as glove failures may not contribute heavily to the probability of having a CAM alarm, the fact that the contamination is local with respect to the workers suggests this might be an important release type for worker intakes. Data shown in Table 4 lends some support to this notion.

Whicker et al. (1990) showed particle size distribution data from several events. The results are reported in Table 5. These

Table 3.
Percent of releases where the CAM alarmed
for different release causes.

Cause of Release	Total # Releases	Percent Cam Alarm
Bagout	13	76
Packing/ Unpacking	5	60
Equip. Failure	16	25
Hood Operation	16	13
Maintenance	69	10
Glove Failure	109	4
Other	83	0

Table 4.

Percent of total number of positive nose swipe results for various release causes.

Release Cause	Percent of Total
Glove Failure	40
Equipment Failure	20
Flange Leak	20
Packing/ Unpacking	20
	100%

Table 5.

Particle size distribution information for several releases in PF-4.

Release Cause	AMAD (Microns)	% Less Than 10 Microns
Decontamination	9.0	55
Maintenance	6.5	70
Accident 1	2.3	87
Accident 2	< 1	100

data show the wide ranges of possible particle sizes and that a significant particle fraction are greater that 10 μm in size. Past Pu particle size studies show similar results and that the AMADs can range from less than 1 μm on up to greater than 10 μm in many cases (Elder et al., 1974; Moss et al., 1961). Larger particle sizes may deposit on surfaces prior to reaching the CAM as well as reducing the probability of the particle penetrating the CAM air intake system to be collected on the filter. McFarland et al. (1990) showed that particle penetration through the CAM head and intake system dropped off quickly as the particle aerodynamic diameter exceeded several microns. Therefore, even if the larger particles reached the CAMs, they may not have reached the collection filter and the CAM may not have alarmed.

Discussion

These results suggest we consider a two component strategy for CAM placement. The first component consists of placing CAMs at the exhaust points within the laboratories to provide for reliable detection of releases given that we cannot predict with much certainty the actual location within the room. Inherent in this strategy is some loss of sensitivity due to dilution. The second component of the placement strategy is to, where possible, place CAMs at sensitive locations determined by process knowledge and historical data. CAM placement at locations where "high risk" operations are conducted can provide for better alarm sensitivity.

However, before deploying many relatively expensive CAMs in a room, one should also consider the added benefit for each CAM. Scripsick et al. (1979) provided evidence that the added benefit of additional CAMs decreased as the number of CAMs in a room increased.

Finally, to satisfy the As Low As Reasonably Achievable (ALARA) philosophy required by our profession, we should strive to better the instrument sensitivity of the CAMs. As the instrument sensitivity gets better, the placement strategy becomes less important and allows for us to use fewer CAMs. Because of the high cost of installation, maintenance, and the purchasing of the CAMs, the benefits of improving the CAM's instrument sensitivity could be worth the effort and would ensure the protection of the workers.

Acknowledgements

I would like to express my thanks to Tom Crites from Lawrence Livermore National Laboratory for his data review. Also, I would like to thank the following individuals for their insightful review and comments: C. Fairchild, J.L. McAtee, R. Huchton, A. McFarland, and J. Dawson.

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