RFP-- 5225 RFP-5225
CONF- 990603--

THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BERYLLIUM CHARACTERIZATION PROJECT

RECEIVED
DEC 21 1999
OSTI

Diane M. Morrell
Kaiser-Hill Company LLC
P.O. Box 464
Golden, CO 80402-0464
(303)966-2563

Jeffrey R. Miller
Radian International LLC
115 Longview Drive
Los Alamos, NM 87544
(505)672-2112

Douglas F. Allen
Radian International LLC
1093 Commerce Park Drive, Suite 100
Oak Ridge, TN 37830
(423)220-8127

ABSTRACT

A site beryllium characterization project was completed at the Rocky Flats Environmental Technology Site (RFETS) in 1997. Information from historical reviews, previous sampling surveys, and a new sampling survey were used to establish a more comprehensive understanding of the locations and levels of beryllium contamination in 35 buildings. A feature of the sampling strategy was to test if process knowledge was a good predictor of where beryllium contamination could be found. Results revealed that this technique was effective at identifying where surface contamination levels might exceed the RFETS smear control level but that it was not effective in identifying where low concentrations of beryllium might be found.

I. INTRODUCTION

Radian International LLC (Radian) conducted a baseline inventory and sampling survey for beryllium contamination in 35 buildings at the RFETS starting in January and concluding in September, 1997. The project was conducted under the direction of the Kaiser-Hill Company, LLC (Kaiser-Hill) Industrial Hygiene Department.

The purpose of the project was to develop a baseline inventory of beryllium locations and operations; identify potentially exposed current workers by location; and conduct air and surface wipe sampling. A desired outcome was to confirm beryllium contamination in suspect areas and verify the absence of beryllium contamination in non-suspect areas. Therefore, unlike other surveys, samples were collected and analyzed from areas where beryllium contamination was expected to be absent.

The objectives were to fulfill one of the requirements of the U.S. Department of Energy (DOE) Notice 440.1, Interim Chronic Beryllium Disease (CBD) Prevention Program; gather data to assist in the ongoing epidemiological investigation of CBD at RFETS; and provide contaminant characterization data useful for decontamination and decommissioning (D&D) efforts.

The scope of work included 35 buildings or areas with a history of beryllium use and/or incidence of CBD or beryllium sensitization in a person who currently or formerly worked in that building. The types of buildings included machine shops, analytical laboratories, waste treatment facilities, laundry facilities, air filter plenum buildings, research and development laboratories, and other processing facilities.

II. METHODS

A detailed Sampling and Analysis Plan was prepared and implemented for the study.[1] The seven-step, data quality objective (DQO) process was applied to help ensure that appropriate information was collected and to take full advantage of existing knowledge. A detailed discussion of the DQO process and its application to building contaminant characterization projects is provided in a companion paper.[2]

A combination of three building evaluation techniques was used. The techniques included: (1) a review of building design and usage to establish process knowledge; (2) collection of new data through surface wipe and air sampling; and (3) evaluation of historical beryllium air and wipe sampling data. The process knowledge method was applied to all 35 buildings and included review of drawings and historical documents, interviews with knowledgeable people, and walk-through engineering inspections. New air and surface wipe sampling data was collected in 21 buildings. Evaluation of historical beryllium sampling data was conducted for 6 buildings.

An underlying hypothesis was that building systems and components could be correctly stratified into one of four contamination categories based on process knowledge. To test that hypothesis, the building systems and components were identified. The seven categories were:

- Floors;
- Miscellaneous horizontal surfaces above 8 feet;
- Miscellaneous horizontal surfaces below 8 feet;
- Process equipment;
- Internal areas (e.g. drawers, cabinets);
- Supply ventilation systems; and,
- Exhaust ventilation systems.

Second, the four contamination categories were defined to describe the anticipated level of contamination. They were:

- Assumed Clean: Areas where beryllium processing was never conducted, air spaces and ventilation systems are not shared with rooms used for beryllium processing, beryllium workers did not visit unless fully decontaminated, and no other contamination routes are known.

- Probably Clean: Areas where beryllium processing was never conducted but the possibility for cross contamination from beryllium areas exists through shared air spaces, shared ventilation systems, and cross contamination by beryllium workers.

- Possibly Contaminated: Areas that appear to have a direct connection to a beryllium processing area or where only small quantities of beryllium were handled (e.g., laboratory).

- Probably Contaminated: Areas where beryllium processing was conducted and the probability for finding contamination is considered high.

Third, the building systems and components were stratified into homogeneous sampling areas (HSAs), that is, areas thought to have a similar level of beryllium contamination. For example, floors in the office area of an analytical laboratory where beryllium analyses were not performed, was assumed to be clean.

Finally, new air and surface wipe sampling data was collected to determine if the *a priori* stratification was correct. To determine where and how to collect samples, a statically based sampling strategy was developed. The Success Calculation Method was used for guidance.[3] The success for properly classifying an HSA was defined in terms of frequency of concern and confidence levels.

The frequency of concern is the percentage of failures for the hypothesis that is acceptable. The confidence level is the certainty that the frequency of concern has been met. An example of a conclusion based on the statistics would be, "we are 95% confident that 95% of the assumed-clean floors do not have measurable beryllium contamination." A confidence level of 95% was applied to all contamination categories. A different frequency of concern was established for each contamination category because of the different degree of failure acceptable for each. A higher degree of failure for probably contaminated categories was allowed because controls were in place and extra precautions would be taken in these areas anyway. On the other hand, a lower degree of failure was acceptable for assumed clean areas because extra precautions would most likely not be taken when working in these areas. The frequencies of concern established for each contamination category are presented in Table 1.

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Table 1
Frequencies of Concern by Contamination Category

Contamination Category	Frequency of Concern	Minimum Number of Samples
Assumed clean	5%	59
Probably clean	10%	29
Possibly contaminated	10%	29
Probably contaminated	20%	14

Surface wipe sampling was conducted to determine whether beryllium contamination was present on surfaces. Determining the correlation, if any, between surface contamination and airborne concentrations was beyond the scope of this project. Wipe sampling was viewed as a measure of housekeeping and was conducted through four steps:

1. Classify the building stratum into the appropriate contamination category for a given location (based on process knowledge);

2. Identify biased sampling locations for the stratum to be sampled;

3. Collect and analyze wipe samples from the identified locations; and

4. Analyze the results.

The field sampling team identified biased sampling locations. Biased sampling is preferred when attempting to demonstrate that contamination *is not* present. This allowed the sampling team to test the locations where contamination was most likely to occur. If it was not present there, then it is reasonable to assume that it was not present at other, less likely, locations either. Examples of biased sampling areas are shown in Table 2.

Wipe samples were collected in accordance with *Beryllium Control Program*, 4-15321-IHPM-5.2; *Rocky Flats Industrial Hygiene Procedures Manual;* and *Rocky Flats Environmental Technology Site (RFETS), Site Beryllium Characterization Sampling and Analysis Plan*. Samples were collected by wiping a 100-cm^2 area with a Whatman #4 filter. A 100-cm^2 template was used to ensure consistency between sample locations unless the odd shape of the sample location prevented the use of a template. In these situations, an experienced sampler estimated the size of the area wiped. After collection, samples were placed in plastic Petri dishes. After a survey for radioactivity, the Petri dishes were sealed with tape, labeled, and placed into a sealed plastic bag for delivery to the laboratory.

Area air sampling was conducted to determine the background airborne concentration of beryllium in buildings. The number of air samples collected was based on the size and occupant load of the buildings where the sampling was conducted. Buildings were classified into three qualitative sizes (small, medium, and large). The number of area samples collected from each building size was 3, 5, and 8, respectively. For background comparisons, outdoor air samples were also collected.

Table 2
Examples of Biased Sampling Areas

HSA	Biased Sample Location
Possibly Contaminated Floor	Corner of room where dust accumulates
	Under an object not routinely cleaned
	Traffic area traversed by beryllium workers outside of main beryllium area
Assumed Clean Internal Areas	Back of bookshelf
	Under cabinet drawer
	Back of cabinet shelf
	Desk drawer
Probably Clean Miscellaneous Horizontal Surfaces	Door jams
	Window sills
	Top of electrical panels
	Top of ledges
	Top of building structural components

The selection of potential air sample locations was based on areas serviced by different HVAC systems. The most appropriate sample collection point was then selected based on the following criteria:

- Accessibility to the field team;
- Protection from tampering and vandalism;
- Ability to place filter cassette at a height of 4 to 6 ft;

- Placement away from open window or door;
- Placement away from radioactive contamination; and
- Placement in an area with free air movement.

The air sampling train consisted of a battery powered vacuum pump, flexible tubing, a metal adapter, and a 3-piece cassette containing a 37-mm, mixed cellulose filter with a 0.8 micron pore size. The sample trains were calibrated before and after each sample was collected.

After the samples were collected and screened for radioactivity, the filter cassette was placed into a sealed plastic bag, labeled, placed in a plastic container sealed with evidence tape, and delivered to the laboratory.

Air and surface wipe samples were analyzed using National Institute for Occupational Safety and Health (NIOSH) Method 7300-Elements by Inductively Coupled Plasma-Mass Spectroscopy. Results were entered into a Microsoft Access® database for analysis and report generation.

Historical beryllium surveys were identified for six buildings and found to contain substantial amounts of good quality data. Because the study objectives and methods were different on these previous studies, the data was not directly comparable but provided a good benchmark. These studies were reviewed and results compiled. Findings were reported along with the new data so a comprehensive picture of site beryllium contamination was available in a single report.

III. RESULTS

A site-wide summary of air and wipe sample results was produced.[4] Results showed that there were measurable quantities of beryllium on surfaces in 32 of the 35 buildings, but that exceedance of the RFETS smear control level of 25 μg/ft^{2}was infrequent. Of the 926 surface wipe samples that Radian collected, 290 (31%) of the surface wipe samples had beryllium above the analytical limit of detection (LOD), which ranged from 0.01 to 0.28 micrograms per square foot (μg/ft^2). Only 15 samples (2%) exceeded the RFETS smear control level of 25 μg/ft^2. These samples were collected in areas classified as probably or possibly contaminated. Exhaust ventilation systems consistently had the highest percentage of detectable sample results.

Results of surface wipe sampling are displayed in Figures 1 and 2.

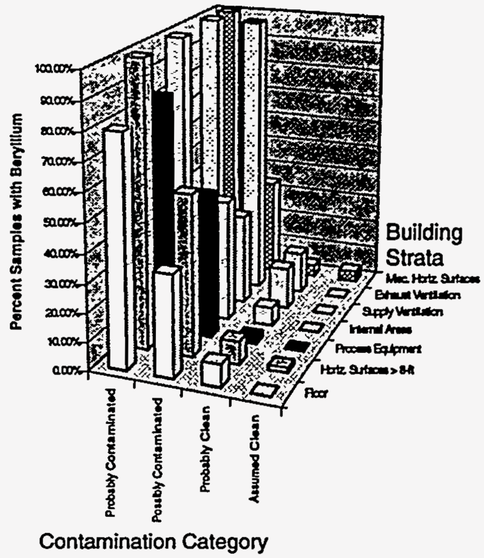

Figure 1. Percent of Samples with Contamination Above the Detection Limit

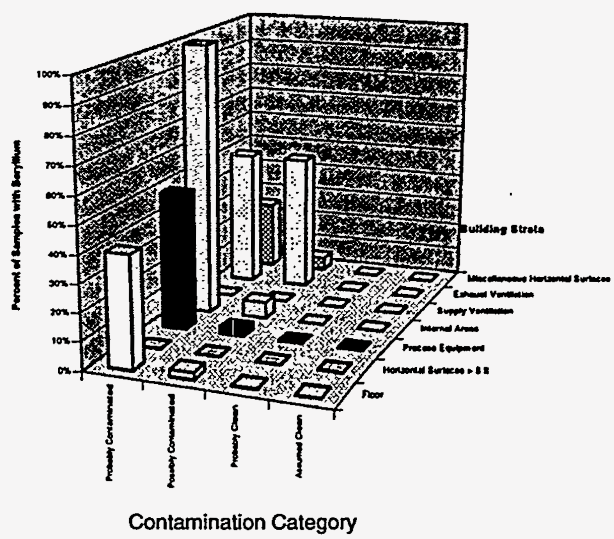

Figure 2. Percent of Samples with Contamination Above 25 μg/ft^2

The frequency of concern for each building strata and contamination category was calculated. Ranges were established for the percent of samples expected to exceed the LOD (0.28 $\mu g/ft^2$, the highest LOD for all sample batches) and the percent expected to exceed the RFETS smear control level (25 $\mu g/ft^2$). The aggregate frequency of concern was exceeded for all contamination categories when compared to the LOD. The aggregate frequency of concern was acceptable for 3 of 4 contamination categories when compared to the smear control level. This suggests that stratification of buildings into components and systems and contamination categories is effective for predicting which areas will have high levels of beryllium contamination but not effective for predicting where low levels of contamination may occur. These results are presented in Table 3.

TABLE 3
Anticipated Percent of Samples With Contamination Above Various Thresholds with 95% Confidence

Contamination Category	Building Strata	Number of Samples	Acceptable Frequency of Concern (%)	Percent > LOD	Percent > 25 $\mu g/ft^2$
Assumed Clean	Exhaust Ventilation	4	5	0 - 81	0 - 53
	Floor	57	5	0 - 10	0 - 6
	Horizontal Surfaces > 8 ft	62	5	2 - 14	0 - 5
	Internal Areas	57	5	0 - 6	0 - 6
	Miscellaneous Horizontal Surfaces	53	5	3 - 19	0 - 6
	Process Equipment	24	5	1 - 22	0 - 12
	Supply Ventilation	56	5	2 - 15	0 - 6
Probably Clean	Exhaust Ventilation	28	10	28 - 67	0 - 11
	Floor	66	10	20 - 43	0 - 5
	Horizontal Surfaces > 8 ft	62	10	10 - 30	0 - 5
	Internal Areas	61	10	26 - 52	0 - 5
	Miscellaneous Horizontal Surfaces	76	10	18 - 40	0 - 4
	Process Equipment	41	10	15 - 43	0 - 8
	Supply Ventilation	34	10	11 - 42	0 - 9
Possibly Contaminated	Exhaust Ventilation	17	10	39 - 86	0 - 17
	Floor	45	10	56 - 84	1 - 12
	Horizontal Surfaces > 8 ft	34	10	63 - 92	0 - 9
	Internal Areas	33	10	46 - 80	1 - 21
	Miscellaneous Horizontal Surfaces	41	10	40 - 72	1 - 17
	Process Equipment	36	10	68 - 94	1 - 15
	Supply Ventilation	19	10	17 - 62	0 - 15
Probably Contaminated	Exhaust Ventilation	2	20	23 - 100	2 - 99
	Floor	5	20	29 - 100	6 - 86
	Horizontal Surfaces > 8 ft	1	20	NA	NA
	Internal Areas	2	20	3 - 100	3 - 100
	Miscellaneous Horizontal Surfaces	4	20	48 - 100	1 - 81
	Process Equipment	6	20	61 - 100	12 - 89
Assumed Clean - % Areas Contaminated (aggregate)			5	3 - 7%	0 - 1%
Probably Clean - % Areas Contaminated (aggregate)			10	25 - 35%	0 - 1%
Possibly Contaminated - % Areas Contaminated (aggregate)			10	61 - 74%	0.1 - 6%
Probably Contaminated - % Areas Contaminated (aggregate)			20	76 - 100%	24 - 69%

None of the 132 area air samples exceeded the RFETS occupational exposure administrative action level of 0.5 μg/cubic meter (m^3) or the U.S. Environmental Protection Agency ambient air standard of 0.01 μg/m^3. Fourteen of the air samples (11%) had beryllium concentrations above the LOD that ranged from 0.001 to 0.006 μg/m^3. All of the detectable quantities were at least ten times below the administrative action level. Detectable quantities were found in areas of all contamination categories (i.e. assumed clean, probably clean, possibly contaminated, and probably contaminated).

Results of the evaluation of historical beryllium surveys indicated that none of the 216 area air samples exceeded the administrative action level. In addition, 51 of 3,012 surface wipe samples exceeded the smear control level (1.7%). Measurable quantities of beryllium were found on 900 of 3,012 samples (30%).

IV. DISCUSSION

There were several important lessons learned while conducting this study that can have an impact on the protection of workers from beryllium exposure now and during future D&D efforts.

Analytical detection capabilities have outpaced occupational exposure limits. The analytical method used for this study, NIOSH Method 7300-Elements by inductively coupled plasma-mass spectroscopy, was able to detect beryllium at concentrations 10-100 times lower than other methods. While we can now detect very low concentrations of beryllium, the health effect from exposure to these levels is not understood. This forces decision making in the face of scientific uncertainty.

Contamination migration patterns must be examined. Low levels of contamination appear to have been deposited by fugitive dusts, transfer of tools, and worker traffic. This seems to be the only explanation for the presence of beryllium contamination in areas where there was no known use of beryllium. Information about these variables was not documented and not always recalled when interviewing people. Thus, relying on process knowledge and historical interviews may not capture this information.

It should not be assumed that supply ventilation systems are free from contamination. While the systems may include air filtration devices, this apparently does not preclude the presence of contamination in the system.

Assume that local exhaust ventilation systems are contaminated unless proven otherwise. These systems are designed to collect contamination. The question is not whether they are contaminated, it is how contaminated are they?

Sampling in radiological controlled areas (RCA) presents quality assurance challenges. It is important to avoid radiological contaminated beryllium samples whenever possible because there are very few labs that will analyze them. Further, the direct counting of the filter papers before they can be released from the RCA introduces additional handling of the sample. Timing issues related to sample release from the RCA also create sample chain of custody issues.

Surfaces that have beryllium and radiological co-contamination are already under control. Methods used to control the spread of radiological contamination are generally effective for controlling beryllium, too. It is essential that co-contamination be recognized and that both contaminants be evaluated before "free-release" of equipment or building components.

Historical data has limits, but it may be sufficient for making qualitative judgments about areas where contamination is known to be present. Exhaustive sampling in areas where historical evidence indicates contamination is highly likely may have little added value. These resources might provide more value if redirected to decontamination or toward characterizing areas where there is more uncertainty.

It is not possible to eliminate the uncertainty surrounding beryllium contamination. A characterization project, such as this, helps quantify contamination levels in buildings but does not address the uncertainty related to beryllium toxicity nor the relationship between surface contamination and airborne exposure. Professional ethics dictate that we apply the best available control technologies until we better understand the health risk associated with beryllium.

V. CONCLUSION

It was concluded that stratifying building components and systems into homogeneous sampling areas prior to sample collection was an effective method for identifying areas where surface contamination exceeded the RFETS smear control level. This technique was not effective for identifying where low levels of contamination were present. Low levels of beryllium contamination are not easily predicted using process knowledge and historical information. Therefore, while historical sampling data, knowledge of process, interviews with knowledgeable people and walkthrough inspections are important, they are insufficient for accurately predicting where beryllium will *not* be present at RFETS. Air and surface wipe sampling are also required.

ACKNOWLEDGMENTS

Research presented in this document was performed by Radian International LLC for Kaiser-Hill Company LLC under subcontract KH700068EP6 for the U.S. Department of Energy.

REFERENCES

1. Radian International, LLC, *Rocky Flats Environmental Technology Site, Beryllium Characterization Work Plan,* Radian International, LLC, Denver, CO (1997).

2. D.A. Allen, "Accelerated Building Characterization to Support Decontamination and Decommissioning,"Spectrum'98, International Conference on Decommissioning and Decontamination and on Nuclear and Hazardous Waste Management, Denver, CO, (1998).

3. L. H. Keith, G. L. Patton, and P. G. Edwards, "Calculator for Estimating Numbers of Environmental Samples and Associated QC Samples," DQO-PRO Version 1.1, Radian International, LLC, Austin, Texas (1996).

4. Radian International, LLC, *Rocky Flats Environmental Technology Site; Site Beryllium Characterization Report,* Radian International LLC, Denver, CO (1997).