BHI-01353
Rev. 1

Airborne Monitoring Technical Basis

Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Environmental Restoration

Submitted by: Bechtel Hanford, Inc.

BHI-01353
Rev. 1

Airborne Monitoring Technical Basis

Author

S. R. Reed
Bechtel Hanford, Inc.

Date Published

April 2001

BHI-01353
Rev. 1
OU: N/A
TSD: N/A
ERA: N/A

APPROVAL PAGE

Title: Airborne Monitoring Technical Basis

Approval: D. E. Gergely, Radiological Control Manager

Dale Gergely 5/2/01
Signature Date

BHI-DIS 5/7/01

The approval signature on this page indicates that this document has been authorized for information release to the public through appropriate channels. No other forms or signatures are required to document this information release.

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 DISCUSSION 1

2.1 REGULATIONS 2

2.2 AIR MONITORING PROGRAM GOALS 3

3.0 AIR SAMPLING PROGRAM REQUIREMENTS 4

3.1 PERFORMANCE AND ACCEPTANCE TESTING EQUIPMENT 4

3.2 SAMPLE ACCOUNTABILITY 5

3.3 CALCULATING MINIMUM AIR SAMPLE VOLUMES AND INTERPRETING AIR SAMPLING RESULTS 5

3.3.1 Calculating Minimum Air Sample Volumes 5
3.3.2 Establishing Derived Air Concentration-Hours 7

3.4 DERIVED AIR CONCENTRATION HOUR TRACKING 9

3.5 INTERPRETING AIR SAMPLING RESULTS 9

4.0 ENVIRONMENTAL RESTORATION CONTRACTOR AIR SAMPLING REQUIREMENTS 11

4.1 CONTINUOUS AIR MONITOR SAMPLING 11

4.1.1 Continuous Air Monitor Alarms 11

4.2 GRAB AIR SAMPLING 12

4.3 LAPEL AIR SAMPLING 13

4.4 FIXED AIR SAMPLING 13

5.0 REFERENCES 14

Table of Contents

APPENDIX

A DEFINITIONS ....A-i

TABLES

1. Removable Contamination Levels that Require Air Samples..12
2. Soil Contamination Levels that Require Air Sampling. 13

ACRONYMS

ADAC	adjusted derived air concentration
ADAC-h	adjusted derived air concentration-hours
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
CAM	continuous air monitor
CFR	*Code of Federal Regulations*
DAC	derived air concentration
DL	detection limit, decision level
DAC-h	derived air concentration-hours
DOE	U.S. Department of Energy
dpm	disintegration per minute
ERC	Environmental Restoration Contractor
MDA	minimum detectable activity
RCT	radiological control technician
RWP	radiological work permit

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerel	0.027	picocuries

1.0 INTRODUCTION

This technical basis document describes the Environmental Restoration Contractor's (ERC's) air monitoring program that is implemented to help control and monitor workers' exposure to airborne radionuclides in the work place and to monitor the effectiveness of work place controls. This document describes the methodology used to develop the criteria for air sampling and monitoring procedures and does not concern effluent or environmental air monitoring samples.

2.0 DISCUSSION

This document establishes the basis for monitoring airborne radioactivity in the workplace that is required to assess worker exposures. The airborne monitoring program is designed with worker protection, regulatory compliance, and as low as reasonably achievable (ALARA) concerns as fundamental tenets. The goal of the program is to balance these fundamental tenets and minimize overall risk from airborne radioactivity to individual workers. Definitions of terms used in this document are provided in Appendix A.

The results of the air monitoring program are used to plan work and to control worker intakes of airborne radioactive material. The air monitoring program is an important part of a comprehensive radiological control program that uses real-time and periodic air sampling, individual monitoring, bioassays, engineering controls, respiratory protection, contamination control, and ALARA dose optimization to minimize overall risks and hazards.

Planning work in areas where airborne radioactivity may be generated is an integral part of radiation protection. Radiological work planning has many elements, however, only those elements that pertain to airborne radioactivity are described herein. Airborne radioactive material may be generated in work areas that contain removable radioactive materials or fixed radioactive materials that may be disturbed by the work. The radiological engineer evaluates the work using procedural direction to estimate airborne radioactivity levels. Factors that should be considered when evaluating the potential for airborne radioactivity include contamination levels, type of work performed, engineering controls, ventilation rates, area volume, and empirical data documented as a result of similar work activities performed.

Work can be performed with minimal oversight under an "umbrella" specification for air sampling when the hazard and probability of generating airborne material are small. If the potential hazards are significant, the radiological engineer must specify necessary controls in addition to those specified by the umbrella specification. The specific instructions may be recorded on a radiological work permit (RWP) request form, which will accompany the RWP or work package. Supporting documentation, as necessary, should be attached to the form or referenced within the document.

The following air sampling guidelines must be followed: (1) use best health physics practices, (2) sample from the breathing zone when possible, (3) use conservative locations when breathing zone sampling is not practical, (4) use personnel air samplers when conservative sampling may not be adequate or intake is likely, (5) do not interfere with safe work practices, and (6) be cognizant of nonradiological hazards at all times.

2.1 REGULATIONS

The following air monitoring requirements are specified in 10 *Code of Federal Regulations* (CFR) 835:

General Requirements (10 CFR 835.401)

- Monitoring of individuals and areas shall be performed as follows:
  - To demonstrate compliance with the regulations listed herein
  - To document radiological conditions
  - To detect changes in radiological conditions
  - To detect the gradual buildup of radioactive material
  - To verify the effectiveness of engineering and process controls in containing radioactive material and reducing radiation exposure
  - To identify and control potential sources of individual exposure to radiation and/or radioactive material.
- Instruments and equipment used for monitoring shall conform to the following:
  - Periodic maintenance and calibration on an established frequency is performed
  - Instruments/equipment are appropriate for the type(s), levels, and energies of the radiation(s) encountered
  - Instruments/equipment are appropriate for existing environmental conditions
  - Routine testing for operability is performed.

<u>Air Monitoring (10 CFR 835.403)</u>

- Monitoring of airborne radioactivity shall be performed as follows:
  - Where an individual is likely to receive an exposure of 40 derived air concentration-hours (DAC-h) or more in a year
  - As necessary to characterize the airborne radioactivity hazard where respiratory protective devices for protection against airborne radionuclides have been prescribed.
- Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material.

2.2 AIR MONITORING PROGRAM GOALS

The primary goals of the airborne monitoring program are to identify and control the internal radiological hazards of worker exposure in order to minimize those hazards. The protection of the worker is accomplished through the use of (1) engineering controls (e.g., ventilation and containment), (2) respiratory protection appropriate for the airborne radioactive material present, and (3) administrative controls (e.g., posting airborne radioactivity areas and setting maximum levels of contamination in radioactive material areas). Air sampling, personnel air monitoring, DAC-h tracking, and confirmatory bioassays are used to evaluate the effectiveness of the protective measures.

The air monitoring program interfaces with the bioassay program and identifies potential intakes of airborne radioactive material that may require bioassay. Internal dose can be assigned by several methods. The U.S. Department of Energy (DOE) prefers the bioassay method of internal dose assignment. The DOE requires bioassays to be used to determine internal dose unless bioassay data are unavailable, inadequate, or if it can be demonstrated that the dose estimated based on air concentration is as accurate (or more accurate).

The DOE recognizes that, for a routine bioassay program, it is difficult to obtain accurate dose estimates for long-lived, alpha-emitting radionuclides using the current state-of-the-art internal dose assessment bioassay techniques. Therefore, a program that uses the results of the air monitoring program (particularly at low dose levels) to conservatively track DAC-h can provide reliable data below the capabilities of the routine bioassay program. The airborne monitoring program should be used to track potential internal dose until the point is reached where additional reliable data can be obtained from the performance of special bioassays. Implementing an effective air monitoring program to track potential internal dose can reduce the number of routine confirmatory bioassays that are required and also provide more meaningful special bioassays.

3.0 AIR SAMPLING PROGRAM REQUIREMENTS

Grab air sampling, portable air sampling (e.g., lapel air sampler), fixed air sampling, and continuous air monitors (CAMs) are used to sample airborne radionuclides in the workplace. The air monitoring program should be commensurate with the expected concentration of airborne radionuclides generated by the work activities and the potential for intakes.

Grab air sampling is used to determine the airborne radioactivity concentration at a given point in time. Grab air sampling should be taken in conservative locations, preferably as close as possible to the worker's breathing zone. Grab air samples should be allowed to decay at least 2 hours prior to analysis because ERC sites experience varying levels of airborne radon that interfere with sample analysis. However, grab air samples should be analyzed within 4 hours of collection to determine if the engineering controls are adequate to maintain the airborne concentration at predicted levels.

Portable air samplers (e.g., lapel air samplers) are personnel air samplers that are worn by an individual to sample from the individual's own breathing zone. Lapel air samplers must be used to monitor personnel intakes when the adjusted derived air concentration (ADAC) estimates and expected stay times indicate potential intake of greater than 0.25 DAC-h per entry. Lapel air samplers may also be used when grab air sampling is required but is not feasible (e.g., during tours, work areas vary greatly, or remote or cramped work areas).

Fixed air sampling equipment is used to monitor general area airborne radionuclide concentrations for calculating potential dose and the need for bioassay. Fixed air sampling should be used to establish baseline airborne radioactive material concentrations for new facilities or operations and to verify containment integrity or installed physical design features such as fume hoods (DOE G 441.1-8). A trending air sampling program should be considered by the radiological engineer based on airflow studies, occupancy time of workers, and tasks performed in a given work area using fixed air sampling equipment.

The CAMs are used to conduct real-time monitoring when the concentration of the radioactive material in the workplace is likely to warrant immediate action to prevent the inhalation of airborne radioactive material. A convenient level for establishing the use of a CAM is the likelihood of greater than one ADAC. The CAM alarm set point may be set at up to 24 adjusted derived air concentration-hours (ADAC-h) when high radon levels interfere with the timely detection of alpha particle emitters (DOE G 441.1-8).

ADAC-h estimates are derived by dividing the DAC-h estimates by the effective protection factor of the respiratory protection equipment used by the worker.

3.1 PERFORMANCE AND ACCEPTANCE TESTING EQUIPMENT

All air monitoring equipment must meet the requirements of 10 CFR 835.401(b). Equipment that meets the testing specifications of American National Standards Institute (ANSI)

Standard N42.17B, *Performance Specifications for Health Physics Instrumentation-Occupational Airborne Radioactivity Monitoring Instrumentation* (ANSI 1989) are considered to be in compliance with this regulation. Equipment with the best combination of economy, quality, desirable characteristics, ruggedness, and maintainability should be selected. The principal qualities desired for in-field-use air-sample counting equipment are low background, high sensitivity for the type of radiation to be measured, high reproducibility, and ease of decontamination. In addition, air monitoring equipment must have consistent sampling rates and be durable.

3.2 SAMPLE ACCOUNTABILITY

Air sample filters are normally placed in a sample holder (e.g., an envelope or planchet) when they are collected to protect the filters from disturbance during transportation. Each sample is assigned with a unique identifying number at the time of counting, and this number is placed on the sample holder and on associated sample counting documentation. The air sample filters are normally counted at the project sites and the data are logged on the sample holder. If it is necessary to send the sample to the Radiological Counting Facility or other analytical laboratory for further analysis, the assigned unique number is maintained for tracking purposes. In addition to the unique number, data (e.g., time and date) on both the sample counting documentation and the sample holder can be used to confirm sample identity.

3.3 CALCULATING MINIMUM AIR SAMPLE VOLUMES AND INTERPRETING AIR SAMPLING RESULTS

The following subsections describe how to determine the minimum air sample volume that is required to reliably detect radionuclides at a specified DAC value and describes how air sampling results are used to estimate the worker's exposure (i.e., DAC-h) based on the results of the air monitoring program. The detection limit, decision level (DL) and minimum detectable activity (MDA) values used to evaluate the effectiveness of the air monitoring program are also described. The DL and MDA are derived in *Technical Basis – Radiological Counting Statistics* (BHI 2001).

3.3.1 Calculating Minimum Air Sample Volumes

The DAC values for many radionuclides and their respective inhaled air-lung retention classes (i.e., D, W, and Y) are listed in 10 CFR 835, Appendix A, "Derived Air Concentrations for Controlling Radiation Exposure to Workers at DOE Facilities." Additional DAC values are listed in 10 CFR 835, Appendix C, "Derived Air Concentrations (DAC) for Workers from External Exposure During Immersion in a Contaminated Atmospheric Cloud." The proper DAC value must be selected for a given radionuclide and its solubility class before the minimum sample volume can be calculated. The minimum sample volume required to reliably detect airborne activity at a desired DAC value is dependent upon the activity concentration of the radionuclide(s), the DL and detection efficiency of the counting system, the collection efficiency of the filter medium, and the degree of self-absorption of the radiation emitted from the filter. Equation E-1 is used to calculate the minimum sample volume.

$$Min.\ Sample\ Vol.(\ ft^3\ ) = \frac{Detection\ Limit\ (\ dpm\ ) * \frac{\mu Ci}{2.22E6\ dpm} * \frac{1}{0.1DAC\left(\frac{\mu Ci}{mL}\right)} * \frac{ft^3}{28{,}317\ mL}}{DE * CE * (\ 1 - SA\ )} \quad \text{(E-1)}$$

where:

Min. sample vol.	=	the minimum sample volume required to reliably detect the radionuclide in question at the desired DAC (ft^3)
2.22E6 dpm/µCi	=	activity conversion factor
28,317 mL/ft^3	=	volume conversion factor
DE	=	detection efficiency of the counting system (unitless)
CE	=	collection efficiency of the filter media (unitless)
SA	=	self-absorption of activity on filter media (unitless)

(Other factors are defined above.)

In accordance with DOE G 441.1-8, *Air Monitoring Guide*, "Determinations of the need for air sampling should include occupancy factors to determine if an individual is likely to receive a 40 DAC-hour exposure in a year. For example, if a worker is present in a work area only 200 hr/yr and enters no other areas of significant airborne radioactivity, the individual could be exposed to an air concentration equivalent to 20% of a DAC without … exceeding 40 DAC-hours in a year." The 0.1 DAC threshold has been chosen for minimum air sample volume calculations based on the occupancy factor of workers in the potential airborne radioactivity areas. An estimated occupancy factor of 400 hr/yr has been applied. When combined with the 0.1 DAC DL, this result in 40 DAC-h per year, which is the level requiring airborne sampling. Therefore, 0.1 DAC should be used to calculate minimum air sample volume.

For example, a radiological control technician (RCT) covering a job wants to determine the minimum volume of a grab air sample required to determine if engineering controls are adequate. Alpha-emitting radionuclides are not present, and the limiting radionuclide is cesium-137, which has a DAC value of 7E-8 µCi/mL (10 CFR 835, Appendix A). Therefore, the minimum sample volume will be calculated using 0.1 DAC, or 7E-9 µCi/mL. The RCT office counting system has a DL of 20 disintegrations per minute (dpm) for beta-gamma emitters and a detection efficiency of 20% (i.e., 0.20). The collection efficiency of the filtering media is 1.0 and self-absorption is assumed to be zero. The minimum sample volume is calculated using Equation E-1, as shown below:

$$Min.\ Sample\ Vol.(\ ft^3\ ) = \frac{20\ dpm * \frac{\mu Ci}{2.22E6\ dpm} * \frac{1}{7E-9\frac{\mu Ci}{mL}} * \frac{ft^3}{28{,}317\ mL}}{0.20 * 1 * (\ 1 - 0\ )} = 2.27E-1\ ft^3$$

Because the minimum sample volume for beta-gamma emitters is very small relative to the high-volume sampling rates, a minimum sample volume of 50 ft^3 has been established to reliably detect 0.1 DAC of beta-gamma emitters. Similarly, after a maximum allowable alpha background count rate has been established for the counting equipment, a minimum sample volume of 200 ft^3 ensures that 0.1 DAC of alpha emitters can be reliably detected.

3.3.2 Establishing Derived Air Concentration-Hours

Integrating the air concentration (in DAC) over the time during which the worker was in the airborne radioactivity area can be used to assess a worker's intake in DAC-h. The DAC-h estimation may be made by multiplying the average air concentration (in total DAC) in an area by the time spent in the area. This method requires tracking the time spent by each worker in an area and careful placement of air samplers to ensure that a representative sample is obtained of the air breathed by the workers.

Personnel air samplers (e.g., lapel air sampler) can be used to collect an air sample from the workers' breathing zone and to estimate DAC-h exposure. The filter media acts as an integrating collector, and it is not necessary to track the elapsed time in an area as long as the sampling rate of the sampler is known and constant. However, the air must be sampled the entire time that the worker is in the airborne radioactivity area to obtain an accurate DAC-h estimate.

A worker's DAC-h exposure is estimated by multiplying the total activity (e.g., dpm) (which can be corrected for collection efficiency as necessary) collected on the filter media by the ratio of the worker's breathing rate to the sampling rate (L/min). The worker's breathing rate is assumed to be 20 L/min (0.7 ft^3/min) for "reference man" under light activity (ICRP 1974). Based on the guidance provided by the ANSI Standard N42.17B, *Performance Specifications for Health Physics Instrumentation-Occupational Airborne Radioactivity Monitoring Instrumentation* (ANSI 1989), the filter collection efficiency can be ignored (i.e., assumed to be 100%) if it is greater than 90%.

The following method is used to estimate a worker's DAC-h exposure based on the analysis of the filter sample taken from the air sampler. First it is necessary to calculate the activity (dpm) that would be expected to collect on a filter that has been exposed for 1 hour to an airborne radionuclide concentration equivalent to the DAC. Equation E-2 is used to calculate the filter sample activity that is equivalent to 1 DAC-h:

$$\frac{dpm}{DAC-h} = \frac{\frac{\mu Ci}{mL}}{DAC_i} * \frac{2.22E6\,dpm}{\mu Ci} * \frac{10^3\,mL}{L} * SR(L/min) * \frac{60\,min}{h} * \frac{1}{CE} \qquad \text{(E-2)}$$

where:

DAC_i	=	tabulated DAC value for the appropriate solubility class of radionuclide *i* (µCi/ml)
SR	=	sampling rate of the air sampler (L/min)
CE	=	filter collection efficiency (unitless)

(All other terms are previously defined.)

For example, the filter sample activity (dpm) equivalent of one DAC-h of exposure to Class Y plutonium-239, having a DAC of 6E-12 µCi/mL (10 CFR 835, Appendix A) is calculated using Equation E-2, as shown below.

$$\frac{dpm_i}{DAC-h}=\frac{\frac{6E-12\ \mu Ci}{mL}}{DAC_{*Class\ Y\ Pu-239}}*\frac{2.22E6\ dpm}{\mu Ci}*\frac{10^3\,mL}{L}*SR\,(8L/\mathrm{min})*\frac{60\ \mathrm{min}}{h}*\frac{1}{CE}=\frac{6.39\ dpm}{DAC-h}$$

where:

dpm_i/DAC-h	=	the activity (dpm) of radionuclide *i* collected on the filter media that is equivalent to 1DAC-h of exposure to radionuclide *i*
SR	=	8 L/min
CE	=	1.0, assumed (i.e., 100% collection efficiency)

(All other terms as previously defined.)

The results from Equation E-2 must be corrected for the difference between the air sampling rate (8 L/min) and the worker's breathing rate (20 L/min), and then scaled to the actual dpm collected on the filter media. Equation E-3 is used to estimate the workers DAC-h exposure:

$$DAC-h=\frac{1\ DAC-h}{dpm_i}*\ filter\ dpm_i*\frac{BR}{SR} \qquad \text{(E-3)}$$

where:

filter dpm_i	=	the activity (dpm) of radionuclide i collected on the air sampler filter media
BR	=	breathing rate (20 L/min)
SR	=	air sampling rate (8L/min).

Continuing with the example above and assuming that the net activity of the filter media was determined to be 5.2 dpm, then the worker's estimated exposure is calculated using Equation E-3, as shown below.

$$DAC-h = \frac{1\ DAC-h}{6.39\ dpm_i} * 5.2 * \frac{20\ L/min}{8\ L/min} = 2.03\ DAC-h$$

If more than one airborne radionuclide is known to be present, then the fraction of the activity on the filter media due to each radionuclide must be determined, and the DAC-h exposure for each radionuclide should be determined. The DAC-h exposures from the individual radionuclides should then be summed to determine the total DAC-h exposure. If it is not possible to determine the fraction of activity on the filter due to each radionuclide but the identity of the radionuclides are known, then the most conservative DAC value should be used in the calculations and all activity should be attributed to that radionuclide.

3.4 DERIVED AIR CONCENTRATION HOUR TRACKING

The estimation of internal dose based on DAC-h values has not been demonstrated to be as accurate or more accurate than internal dose based on bioassay data; therefore, a DAC-h value is only an indication of a potential internal exposure for the affected worker. A tracking threshold of 0.5 DAC-h is selected to approximate an internal exposure of 1 mrem committed effective dose equivalent. Each DAC-h determination of 0.5 DAC-h or greater will be tracked to the affected worker. The tracked DAC-h values accumulate on a calendar-year basis. Requests for special bioassays are considered when cumulative DAC-h levels for the worker reach 20 DAC-h.

3.5 INTERPRETING AIR SAMPLING RESULTS

Radon progeny are the single most important factor that affects the initial air sample results at ERC project sites on the Hanford Site. As a result of the high levels of both radon-222 and radon-220 (thoron) and their progeny in the air and the generally low fractional air turnover rates at ERC facilities, it is not possible to obtain prompt, meaningful analysis of many air sample filters. No generic radon compensation methodology can be applied to air samples because of the wide range of conditions throughout the Hanford Site and the variability of weather conditions.

Radon interference can be minimized by (1) taking the smallest sample volumes possible to minimize the quantity of radon/thoron and their progeny collected, (2) purchasing equipment that minimizes radon collection, and (3) purchasing equipment that mathematically and reproducibly analyzes the radon/thoron contribution on a sample and accounts for the interference. Even with the use of radon interference minimization, it may be necessary to allow samples containing radon to decay before analysis. Unfortunately, the delay in analysis may cause a delayed reaction to potentially high levels of man-made airborne alpha activity.

It is possible to evaluate airborne radioactive levels that will allow work to continue without creating additional hazards through the introduction of respirators and to simultaneously minimize the risk of substantial intake and dose to workers.

To assist with interpretation of air sample results in the presence of natural airborne radioactivity, workplace indicators are used to determine if an area needs to be posted and controlled as an airborne radioactivity area. The following examples of workplace conditions are provided to help determine if significant airborne radioactivity is present above natural background levels. If the answer to any of the following questions is "yes" and indicates significant airborne radioactivity, the radiological engineer needs to examine the need for further controls:

- Is there removable alpha contamination above 5,000 dpm/100 cm^2 in a moderately disruptive activity?

  NOTE: The removable alpha contamination level is based upon a resuspension factor of 10^{-5} m^{-1} and a derived air concentration value of 2E-12 μCi/cc (Class Y, plutonium-239 DAC). The result of the calculation was rounded up and is within the calculation error band.

- Compare job coverage radiological data (e.g., air samples and contamination surveys) against pre-job planning data. Is there a change?

- Were radiological controls not implemented as directed in the work package, RWP, etc.?

- Have radiological concerns been identified that were not evaluated during the planning of work?

- Are there other air sample indicators that can be evaluated?

  - Are the activity levels on the air samples not consistent with natural concentrations observed in the area?

  - Are CAM charts in non-work areas also trending upward?

- Are there indications of increasing contamination levels outside of contamination areas?

  - Personnel clothing contamination?

  - Increasing levels in "clean" areas adjacent to work site?

- Is the rate of decay of the airborne sample not consistent with known naturally occurring radioactive decays?

- Can an individual be present in the area without respiratory protection and receive an intake exceeding 12 DAC-h in a week?

4.0 ENVIRONMENTAL RESTORATION CONTRACTOR AIR SAMPLING REQUIREMENTS

The ERC implements a graded approach to air sampling. 10 CFR 835 requires air monitoring when an individual is likely to receive an exposure of 40 DAC-h (or more) in a year, or as necessary to characterize the airborne radioactivity hazard when respiratory protection (e.g., respirators) are being used. However, as additional engineering controls and less respiratory protection are applied during work processes, more conservative action levels (i.e., less than 40 DAC-h) for air monitoring must be applied to confirm or deny the effectiveness of the engineering controls.

The ERC implements the following general rules to ensure that the air monitoring program follows a conservative and graded approach.

4.1 CONTINUOUS AIR MONITOR SAMPLING

10 CFR 835 requires real-time air monitoring to be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material.

The CAMs should be used to monitor airborne radioactivity in the workplace when the concentration of airborne radionuclides has the potential to be greater than 1 ADAC. Factors to be considered when considering CAM use include the following:

- Actual data from like work performed
- Time in area to complete the task
- Accessibility to install the CAM
- If placement of the CAM will provide adequate indication of airborne changes at the work location.

4.1.1 Continuous Air Monitor Alarms

When a CAM alarms, workers are trained to immediately stop work activities, exit the area, and notify Radiological Control staff. The RCTs present during the alarm may aid in the evacuation by controlling the egress of the workers in order to minimize personnel intakes and the spread of contamination.

All available data should be used to investigate the cause of an alarm. If the alarm was valid, an investigation should be conducted to determine the potential for personnel intakes, and the results of the investigation should be documented. If the alarm is found to be false, measures should be taken to reduce the potential for recurrence of the false alarm. The actions taken (e.g., alarm set point adjustment or CAM placement) should be documented.

4.2 GRAB AIR SAMPLING

Grab air sampling is required in the following instances:

- When working in areas posted and controlled for contamination purposes where the RWP limiting conditions exceed any of the contamination levels identified in Table 1 (not to include RCTs performing pre-job surveys in posted contamination areas, tours, and hands-off inspections). When representative grab air sampling of a job is not feasible, lapel air sampling on at least the person expected to be the highest exposed individual shall be used in conjunction with grab air sampling.

Table 1. Removable Contamination Levels that Require Air Samples.

Removable alpha contamination (Pu and Am)	100 dpm/100 cm^2
Removable beta-gamma contamination	100,000 dpm/100 cm^2
Removable uranium and progeny	10,000 dpm/100 cm^2

- When working in posted airborne radioactivity areas. When representative grab air sampling of a job is not feasible, lapel air sampling on at least the person expected to be the highest exposed individual will be used in conjunction with grab air sampling. For RCT surveys, tours, and hands-off inspections, place a lapel air sample on the person expected to have the highest potential for exposure.

- When wearing respiratory protection for radiological protection purposes. When representative grab air sampling of a job is not feasible, lapel air sampling on at least the person expected to be the highest exposed individual will be used in conjunction with grab air sampling. For RCT surveys, tours, and hands-off inspections, place a lapel air sample on the person expected to have the highest potential for exposure.

- When working on remedial action projects where the contamination levels are equal to or exceed any of the values identified in Table 2 (not to include RCTs performing pre-job surveys in posted contamination areas, tours, and hands-off inspections). When representative grab air sampling of a job is not feasible, lapel air sampling on at least the person expected to be the highest exposed individual will be used in conjunction with grab air sampling.

Table 2. Soil Contamination Levels that Require Air Sampling.

Total alpha contamination in soil (Pu and Am)	200 pCi/gram
Total beta-gamma contamination in soil[a]	800,000 pCi/gram
Total uranium contamination in soil (above natural background)	30,000 pCi/gram

[a] This value may be adjusted where isotopic data are present. Calculations used to determine isotopic-specific contamination levels shall use the constants found in the air sampling technical basis document.

- When soil samples have values equal to or exceed the values listed in Table 2. The radiological engineer will require air sampling on the applicable RWPs for the area.

- Whenever the RWP request form requires air sampling.

4.3 LAPEL AIR SAMPLING

Lapel air sampling is conducted whenever an individual exposure estimate is greater than 0.25 DAC-h per entry. When representative grab air sampling of a job is not feasible, lapel air sampling on at least the person (expected to be the highest exposed individual) shall be used in conjunction with grab air sampling.

4.4 FIXED AIR SAMPLING

Fixed air sampling should be considered in the design and modification of facilities where unconfined radioactive material would be used or releases of airborne radioactive material would be anticipated. Results from these air samples are particularly useful during a new operation to establish a baseline for airborne concentrations.

Fixed air sampling should also be considered to verify the use of designed and installed features used for engineering controls, such as fume hoods and high-efficiency particulate air-filtered air-handling units.

5.0 REFERENCES

10 CFR 835, "Radiation Protection for Occupational Workers," *Code of Federal Regulations*, as amended.

ANSI, 1989, *Performance Specifications for Health Physics Instrumentation–Occupational Airborne Radioactivity Monitoring Instrumentation*, ANSI N42.17B, American National Standards Institute, New York, New York.

BHI, 2001, *Technical Basis–Counting Statistics for Radiological Control*, BHI-01215, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

DOE G 441.1-8, *Air Monitoring Guide*, as amended, U.S. Department of Energy, Washington, D.C.

EPA, 1988, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, Federal Guidance Report No. 11, U.S. Environmental Protection Agency, Washington, D.C.

ICRP, 1974, *Report of the Task Group on Reference Man*, International Commission on Radiological Protection, ICRP Publication 23, Pergamon Press, Oxford, United Kingdom.

APPENDIX A

DEFINITIONS

APPENDIX A

DEFINITIONS

<u>Adjusted derived air concentration (ADAC)</u>: The unit produced when the total derived air concentration (DAC) of the breathing air in the workplace is divided by the effective protection factor for the respiratory protection used. The ADAC is typically a conservative estimate of the DAC concentration breathed by the worker. Protective response decisions for workers should be based on ADAC.

<u>Airborne radioactive material or airborne radioactivity</u>: Radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

<u>Air monitoring</u>: Actions to detect and quantify airborne radiological conditions by collecting an air sample and the subsequent analysis, either in real-time or offline laboratory analysis, of the amount and type of radioactive material present in the atmosphere.

<u>Air sampling:</u> A form of air monitoring in which the air sample is collected and analyzed at a later time, sometimes referred to as retrospective air monitoring.

<u>Annual limit on intake (ALI)</u>: The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. The ALI values for intake by ingestion and inhalation of selected radionuclides are based on Table 1 of Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* (EPA 1988).

<u>Detection limit/decision level</u>: A value above the background of a counting system set so the chance of a false positive is a predetermined value. For workplace airborne monitoring, the false positive rate shall be 5%. For a sample at the decision level, the false negative rate is 50%. Any value at or above the decision level is considered a positive count. The airborne monitoring program uses the decision level statistic to separate background readings from positive readings. The derivation of the decision level is shown in *Technical Bases--Counting Statistics for Radiological Control* (BHI 2001).

<u>Derived air concentration (DAC)</u>: For the radionuclides listed in Appendix A of 10 CFR 835, the airborne concentration that equals the annual limit on intake divided by the volume of air breathed by an average worker for a working year of 2,000 hours (assuming a breathing volume of 2,400 m^3). For the radionuclides listed in Appendix C of 10 CFR 835, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite atmospheric cloud. The value is based upon the derived airborne concentration found in Table 1 of Federal Guidance Report No. 11 (EPA 1988).

<u>Derived air concentration-hour (DAC-h)</u>: The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide in hours.

Minimum detectable activity (MDA): A value above the background and above the DL of a counting system set so the chance of false negative below the DL is a predetermined value. For workplace airborne monitoring, the false negative rate shall be 5%. Given the definition of MDA, the chance of a false positive is negligible. The MDA is only used to determine the capability of a counting system to meet the program's goals. (See BHI [2001] for the derivation of MDA.)

Real-time air monitoring: Measurement of the concentrations or quantities of airborne radioactive materials on a continuous basis.

Total derived air concentration (total DAC): The unit produced by the summation of DAC fractions. The contribution of each airborne contaminant should be considered, and both the radioisotope and the chemical form should be considered when summing DAC. Airborne contaminants that contribute less than 1% of the dose delivered by airborne contamination can be neglected unless the sum of the neglected doses is greater than 10% of the total.

DISTRIBUTION

ERC Team

J. D. Arana, BHI	L5-64
J. A. Armstrong, BHI	X5-60
P. H. Brenberger, ESHI	X0-34
D. M. Brehm, BHI	L5-64
G. M. Ceffalo, BHI	H0-15
J. W. DeMers, BHI	L5-64
S. K. DeMers, BHI	L5-64
D. H. Denham, BHI	L5-64
M. R. Fishburn, BHI	L5-64
R. C. Free, BHI	L5-64
K. C. Funke, BHI	T6-05
D. E. Gergely, BHI	H0-15
G. J. Gibbons, BHI	L5-64
J. L. Hart, BHI	L5-64
T. D. Kraus, BHI	L5-64
T. L. LaFreniere, ESHI	X0-34
S. D. Landsman, BHI	X3-40
K. A. Mathews, ESHI	X0-34
J. L. Pappin, BHI	L5-64
S. R. Reed, BHI	L5-64
V. E. Shockley, BHI	H0-15
R. B. Sitsler, BHI	S3-20
T. J. Snider, BHI	L4-84
B. E. Vesper, BHI	L5-64
J.C. Wiles, BHI	T7-05
S. L. Winslow, BHI	L5-64
C. E. Young, BHI	L5-64
F. G. Zwiesler, ESHI	X0-34
Document and Information Services (3)	H0-09
DOE-RL Public Reading Room	H2-53
Hanford Technical Library	P8-33
RCCS File/LB L5-4	L5-64
RadCon Letterbook	H0-15
RadCon Operations File/LB (2)	L5-64