Air Sampling and Analysis

Nuclear Secured / Radiation Safety

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History and Approvals

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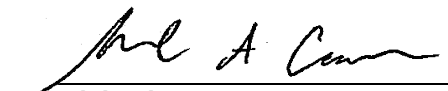
Preparer: 

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1. Purpose and Scope

1.1. Purpose

The purpose of this procedure is to establish a uniform set of guidelines for performing radiological air sampling and analysis. This is to ensure compliance with the United States Nuclear Regulatory Commission (US NRC) regulations as set forth in Subparts C, D and F of 10 CFR 20, Energy - Standards for Protection against Radiation and other guidance documents including US NRC, Regulatory Guide 8.25, *Air Sampling in the Workplace* and US NRC, NUREG-1400, *Air Sampling in the Workplace*. Any specific air sampling protocols including detection sensitivity requirements, types of air sampling to be performed, sampling frequencies and Data Quality Objectives (DQOs) will be included in the site-specific plans or other project specific documentation.

1.2. Scope

This procedure applies to all health physics personnel and subcontractors at field project sites that perform radiological air sampling under the Nuclear Secured (NS) Radiation Protection Program (RPP) in support of personnel monitoring and the monitoring of any potential environmental releases.

This procedure does not address the operation of continuous air monitors (CAMs) for performing “real time” air monitoring. Specific instrument procedures for the use and operation of CAMs should be prepared and used when “real time” monitoring is required.

2. References

2.1. 10CFR20, Subpart C, *Energy – Standards for Protection Against Radiation, Occupational Dose Limits*

2.2. 10CFR20, Subpart D, *Energy – Standards for Protection Against Radiation, Radiation Dose Limits for Individual Members of the Public*

2.3. 10CFR20, Subpart F, *Energy – Survey and Monitoring*

2.4. 10CFR20, Appendix B, *Energy –Standards for Protection Against Radiation; Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage*

2.5. US NRC, Regulatory Guide 8.25, *Air Sampling in the Workplace*

2.6. US NRC, NUREG-1400, *Air Sampling in the Workplace*

2.7. Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*

2.8. AE-SH-PR-002, *Incident Reporting and Notification*

2.9. NS-RS-PG-001, *Radiation Protection Program*

2.10. NS-RS-PR-102, *Project Records Management*

2.11. NS-RS-PR-300, *Performance of Surveys*

2.12. NS-RS-PR-505, *DAC-Hr Tracking*

3. General

3.1. Definitions

3.1.1. *Airborne Radioactive Material or Airborne Radioactivity* - Any radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

3.1.2. *Airborne Radioactivity Area* – A room, enclosure or area in which airborne radioactive materials composed wholly or partially of licensed material exist in concentrations (1) in excess of the Derived Airborne Concentration (DAC) as specified in 10CFR20 Appendix B Table 1 or (2) to such a degree that an individual present in the area without respiratory protection equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the Annual Limit on Intake (ALI) or 12 DAC-hours.

3.1.3. *Annual Limit on Intake (ALI)* – The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller valued of intake of a given radionuclide in a year by reference man that would result in a committed effective dose equivalent of 5 rem (0.05 Sv) or a committed dose equivalent of 50 rem (0.5 Sv) to any individual organ or tissue.

3.1.4. *Breathing* Zone *(BZ)* – General area representative of an individual's breathing air space.

3.1.5. *Class (lung class or inhalation class)* - A classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y which applies to the range of clearance half-times: for Class D (Days) of less than 10 days, for Class W (Weeks) from 10 to 100 days, and for Class Y (Years) of greater than 100 days. More recent ICRP classifications include F/M/S for fast, moderate and slow.

3.1.6. *Committed Dose Equivalent (CDE)* ($H_{T,50}$) - The dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

3.1.7. *Committed Effective Dose Equivalent (CEDE) ($H_{E,50}$)* - The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues. $H_{E,50} = \Sigma W_T * H_{T,50}$

3.1.8. *Derived Air Concentration (DAC)* - The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours at 1.2 m^3 /hour (light work), results in an intake of one ALI.

3.1.9. *Derived Air Concentration-Hour (DAC-Hr)* - The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the derived air concentration for each radionuclide) and the time of exposure to that radionuclide, in hours.

3.1.10. *Minimum Detectable Activity (MDA)* – An estimate of the smallest true value of the measurand that ensures a specific high probability of detection.

3.1.11. *Minimum Detectable Concentration (MDC)* - The Minimum Detectable Activity (MDA) divided by the air volume of the sample.

3.1.12. *Public Dose* - Dose received by a member of the public from exposure to radiation or to radioactive material released by a licensee, or to any another source of radiation under control of the licensee. Public dose does not include occupational dose or doses received from background radiation, from exposure to individuals administered radioactive materials and released under §35.75 or from voluntary participation in medical research programs.

3.1.13. *Restricted Area* - Any area to which access is limited by the licensee for the purpose of protecting individuals against undue risk from exposure to radiation and radioactive materials.

3.2. Responsibilities

Depending on personnel qualifications and the size of the project, project personnel may be assigned multiple roles and/or responsibilities.

3.2.1. NS Radiation Safety Officer

The NS Radiation Safety Officer (RSO) maintains and oversees the implementation of the NS RPP. The RSO shall ensure that radiation safety, radioactive materials management, and radiological operations procedures and programs are kept up to date such that they comply with current regulations and incorporate current and relevant industry practices and regulatory guidance.

3.2.2. Project Manager

The Project Manager (PM) is responsible for ensuring that the proper program procedures and programs are implemented on the project site as required by customer

agreements and contracts. The PM is responsible for ensuring that these programs and procedures are properly incorporated into project specific plans and procedures. The PM is responsible for ensuring that the NS RPP and client programs and procedures, as applicable, are available for use by project personnel.

3.2.3. Project Health Physicist

The Project Health Physicist (PHP) is responsible for assisting the RSO in providing health physics support to the PM and Radiation Protection Supervisor (RPS). This includes technical support to ensure procedural and regulatory compliance and to ensure that the project-specific Data Quality Objectives (DQOs) are met.

3.2.4. Radiation Protection Supervisor

The Radiation Protection Supervisor (RPS) is responsible for implementing the NS RPP at the project location. The RPS manages and oversees the project personnel in regard to radiation and respiratory protection and reports directly to both the PM and the RSO.

3.2.5. Project Personnel

All project personnel are responsible for safety at the project site including radiation safety and have the responsibility for maintaining exposures to themselves and their peers to ALARA. Each individual has the ability and responsibility to stop work as necessary and to bring any safety issues including radiation safety to the attention of the RPS, the PM, and/or the RSO.

3.3. Precautions and Limitations

3.3.1. For exterior air monitoring, protect the sampling equipment and sampling media from weather and ensure the power supply has a ground fault interrupter.

3.3.2. Use precaution when handling air sampling media to ensure the sample it is not cross-contaminated.

3.3.3. High volume grab samples are typically used to calculate airborne activity concentrations to determine the proper radiological posting and PPE requirements rather than assess personnel dose; however, they may be used to assess personnel exposure calculations for short duration and high-risk work tasks.

3.3.4. High volume air sampling moves a lot of air and any exhaust can easily stir up activity creating more airborne contamination.

3.3.5. Due to the low volume of BZ samplers, typically 2 to 3 liters per minute, BZ sampling needs to be performed for an extended period of time to ensure adequate sampling volumes in order to get the required detection sensitivities.

3.3.6. If using a remote sampling head, ensure the air sampler has been properly calibrated with the remote sampling configuration.

3.3.7. For occupational monitoring, samplers may be started and stopped, as needed, to coincide with work. For non-occupational and public monitoring, air samplers should be run continuously for extended periods of time and changed out at a frequency as determined by the PHP.

3.3.8. Caution should be taken when interpreting air sample results to account for Radon/Thoron daughters. These progenies may interfere with the air sample analysis by increasing the count rate making it difficult to distinguish between background and actual airborne activity due to licensed activities, particularly when samples are analyzed shortly after collection and not allowing for Radon decay.

3.3.9. Air samples may be counted sooner than 48 to 72 hours, but those results should be considered preliminary due to the potential interference of Radon/Thoron progeny unless the measured activity is less than the required MDC (e.g., high DAC limit).

4. Pre-Requisites / Requirements

4.1. Air sampling shall be representative of the breathing zone to properly estimate personnel exposures and intakes.

4.2. Do not place air samplers on the ground or the floor because these are not representative of the breathing zone and may inadvertently stir up and collect activity.

4.3. Air sampling locations shall be documented, specifically sampling locations used for environmental and emissions monitoring used for public dose assessments.

5. Procedure

5.1. General Guidance

5.1.1. Air sampling shall be performed when an individual is likely to receive an exposure of 200 DAC-hours or more in a year (i.e., 0.1 ALI or 500 mrem CEDE).

5.1.2. Air sampling shall be performed in any posted Airborne Radioactivity Area or whenever respiratory protective devices are used for the protection against airborne radioactivity.

5.1.3. Air sampling should be performed when there is a potential to generate airborne radioactivity based on the radionuclides of concern, the contamination levels in the work area and the potential for planned work activities to generate airborne radioactivity. Table 5-1 provides guidance for determining the need to perform air sampling based on the potential for personnel exposure.

5.1.4. If containment enclosures are used for personnel protection, air samples shall be taken outside of the containment to verify the enclosure is operating as designed either through general area or BZ sampling.

5.1.5. If effluent streams are being filtered (i.e., HEPA filtered exhaust) and discharged to an uncontrolled indoor area or to an outdoor environment, continuous low volume air sampling shall be performed.

Table 5-1
Air Sampling Recommendations [1]

Estimated Annual Intake (ALI)	Airborne Activity (DAC)	Recommendations
< 0.1	≤ 0.01	Air sampling is generally not necessary; however, some routine sampling may be conducted to verify the levels.
	> 0.01 and < 0.1	Intermittent air sampling during work activities should be performed to verify levels remain low.
	≥ 0.1	Continuous General Area sampling during work activities should be performed.
≥ 0.1	≤ 0.3	Continuous General Area air sampling is required to monitor personnel exposure and posting requirements.
	> 0.3	Continuous General Area air sampling is required to monitor personnel exposure and to assess any respiratory protection requirements. Breathing zone (BZ) air samples should be considered.

5.2. Monitoring Limits – DAC Determination

5.2.1. Determine the radionuclide(s) of concern and their relative quantities based on existing surveys and characterization data as available.

5.2.2. For exposure to soluble uranium, chemical toxicity may be the limiting factor. Consult 10CFR20, Appendix B, *Energy –Standards for Protection Against Radiation; Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage* – Footnote 3 for additional guidance.

[1] Table 1; US NRC, Regulatory Guide 8.25, *Air Sampling in the Workplace*

5.2.3. Identify the radionuclide(s) chemical form and the proper inhalation Class (i.e., D, W or Y) in order to apply the correct DAC values or effluent limits. Use the guidance in Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* to help determine the inhalation Class. If the form and Class are not known, apply the most limiting value for that radionuclide.

5.2.4. The DAC values as provided in Table 1 of 10CFR20, Appendix B, *Energy – Standards for Protection Against Radiation; Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage* and Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* shall be used to establish airborne exposure DAC limits for both on-site occupational and non-occupational personnel.

5.2.5. In the event that the radionuclide distribution is not known or well defined, apply the most limiting or most predominant DAC value as directed by the PHP or RSO.

5.2.6. For a mixture of radionuclides where the identity of some or all radionuclides is unknown, use the Unlisted Radionuclides at the end of 10CFR20, Appendix B, *Energy –Standards for Protection Against Radiation; Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage* for unknown alpha and beta emitters based on direction from the PHP.

5.2.7. A site-specific DAC limit may be established by the PHP or RSO for radionuclide mixtures with a known distribution using the relative fraction of each radionuclide and its corresponding DAC value or limit as follows:

$$DAC_{gross} = \frac{1}{\sum_{i=1}^{n} \frac{f_i}{DAC_i}}$$

Where: f_i = Relative activity fraction of radionuclide i.
DAC_i = Applicable DAC value or effluent limit for radionuclide i.

5.2.8. Adjust the gross DAC value based on the counting application to be performed (e.g., gross alpha or gross beta) using the modes of decay and emissions yield for each radionuclide of concern. This will correct the gross DAC value accordingly based on the counting method and the detectable fraction of activity using the follow formula.

$$DAC_{(\alpha,\beta)} = DAC_{gross} \times \sum_{i=1}^{n} (f_i \times y_i)_{\alpha,\beta}$$

Where: y_i = emission yield

5.2.9. Document the adjusted DAC calculation on Attachment 7.1 or equivalent and have the PHP or RSO approve the limits.

5.2.10. For monitoring non-occupational project workers outside posted areas, consult the PHP or RSO on the proper application of the limits. The occupational limits specified in Table 1 of 10CFR20, Appendix B, *Energy –Standards for Protection Against Radiation; Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage* and US NRC, NUREG-1400, *Air Sampling in the Workplace* are based on an annual intake of 1 ALI or 5,000 mR/year. Because the non-occupational project worker limit is 100 mR/yr, the established occupational dose limits may be divided by a factor of 50 to account for the reduced exposure limits for air sampling outside Restricted Areas.

5.2.11. For monitoring the Public, 10 CFR 20.1101 (d) states that air emissions to the public shall be maintained such that an individual member of the public likely to receive the highest dose will not exceed a TEDE of 10 mrem for the year from inhalation.

5.2.12. The Effluent limits specified in Table 2 of 10CFR20, Appendix B, *Energy –Standards for Protection Against Radiation; Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage* shall be used when establishing DAC limits for the public using the guidance provided in Steps 5.2.5 through 5.2.8 above.

5.2.12.1. It should be noted that the Table 2 limits if inhaled continuously over the course of a year would result in a TEDE of 50 mrem to a member of the public. Considering the TEDE limit to a member of the public is 10 mrem per year as specified in Step 5.2.11, any adjusted DAC shall be reduced by a factor of 5 (i.e., 20%) to account for the lower TEDE dose limit.

5.2.12.2. Occupancy factors may be utilized to further adjust the public DAC limit by the PHP or RSO as necessary; however, justification shall be provided and documented.

5.3. Air Sampling Equipment and Media

5.3.1. The selection of air sampling equipment should be based on the type of personnel monitoring to be performed and the use of the air sampling results.

5.3.2. The types of air samples that may be part of the air sampling program include:

- Breathing Zone (BZ) air sampling using personal air monitors (PAMs) or lapel samplers,
- General Area monitoring (high and/or low volume air sampling),

- Perimeter monitoring for non-occupational workers outside Restricted Areas,
- Environmental and site exhaust (e.g., HEPA exhaust) points and boundaries.

An adequate air sampling program will typically consist of a combination of several of these as directed by the PHP or RSO.

5.3.3. Consider the power supply requirements when selecting air sampling equipment and requirements for ground fault circuit interrupters (GFCI).

5.3.4. Select the proper air sample filter media based on the type of air sampling equipment used. Air filters are usually paper or glass-fiber filters capable of collecting 1 µm (micron) or finer particles. Sample media must also be appropriate for the face velocity or flow rate and the expected filter loading for the sampler being used.

5.4. General Area Air Sampling

5.4.1. Low volume air samplers should be used for general area sampling as they run for longer periods of time and are used to document time weighted average activities over the duration of a work shift.

5.4.2. High volume air samples should only be used for high risk and short duration work tasks or to pull a quick grab sample to verify airborne activity levels and area postings and should be placed between the worker and the potential source of airborne activity to the maximum extent practical.

5.4.3. Place general area air samples to be representative of the workers breathing zone while considering the work tasks that will be performed, air flow patterns, predominant wind directions, the potential sources of airborne activity and the general position of personnel while in the work zone.

5.4.4. Position the air sampling head at least waist high, preferably near the breathing zone height (e.g., approximately 3 to 6 feet high), and typically between the worker and the sources of airborne activity.

5.4.5. Remote sampling heads and tygon tubing may be used for low volume air sampling to keep air sample pumps outside contaminated areas as applicable.

5.5. Breathing Zone Air Sampling

5.5.1. Personal air monitors, (i.e., lapel samplers), should be used for BZ sampling to estimate personnel exposure when general area air sampling is not adequate or there is a risk of non-uniform airborne contamination that may not be represented by the general areas low volume air samplers.

5.5.2. Attach the sampler pump near the individual’s waist with the sampling head located in an area representative of the breathing zone (i.e., preferably over their shoulder within about 1 foot of the individual’s face).

5.5.3. Position the pump, sampling head and tubing such that they do not restrict the workers movement. The sampling tube may be taped or clipped to the individuals PPE to ensure it remains in place.

5.5.4. Instruct the worker on the location of the air sample head such that they do not inadvertently touch the sampling head with contaminated gloves to prevent cross contamination and inaccurate air sampling results.

5.6. Perimeter and Release Point Air Sampling

5.6.1. Use low volume air samplers operated over an extended duration, (e.g., 1 shift to 1 week) to measure any potential environmental (off-site) releases and exposures to either the public or non-occupational personnel. This will provide a larger sample volume in order to meet the lower detection limits required because of the lower DAC limits for the public.

5.6.2. Areas surrounding posted airborne contamination areas shall be monitored such as air locks and areas immediately outside physical boundaries including control points and area access locations to ensure adequate containment.

5.6.3. Release point air samples shall be obtained in or near any exhaust or ventilation point (i.e., stack, HEPA exhaust, etc.). For general monitoring, the air sampler should be placed outside the exhaust location unless isokinetic air sampling is required.

5.6.4. Sample heads positioned directly inside a stack or ventilation duct may require isokinetic sampling which is not addressed in this procedure. If isokinetic sampling is required, consult the PHP or RSO for guidance.

5.6.5. For perimeter air sampling, air samples should be placed in areas that are representative of uncontrolled areas that are frequented by personnel. For outside monitoring, the use of more than one sampler is recommended to ensure that possible effluent release points are adequately sampled where wind directions may shift.

5.6.6. For monitoring any potential site release to the general public, air samplers should be placed well away from any work area and near the site boundaries where general public access is permitted. Ensure both the closest site boundary and the predominant downwind locations are monitored.

5.7. Air Sample Collection

5.7.1. Identify and note the predominant wind directions, facility lay-out and general air flow patterns as necessary (i.e., make-up air and exhaust points).

5.7.2. Determine the proper sampling equipment and air sample media (e.g., filter paper) in accordance with Section 5.3 and sampling locations in accordance with Sections 5.4 and 5.6 depending on the type of air sampling performed.

5.7.3. Name and document the location of all fixed point air samplers on an Air Sample Location Summary, Attachment 7.2.

5.7.4. When using PAMs, assign the sampler to an individual and provide basic instructions to the person on operation and care to prevent cross contamination of the sampling media.

5.7.5. Ensure the filter media is placed in the sample head properly with the rough side outward facing the air flow.

5.7.6. Start the air sampler and record the sample start date/time and the initial flow rate (as well as any other pertinent information).

5.7.7. Run the air sampler over the duration of the task considering the amount of time necessary to meet the MDC requirements established in Section 5.9.

5.7.8. At the end of the monitoring period, stop the air sampler and record the stop date and time and final air flow rate.

5.7.9. Remove the air sampling media and place it in an envelope (e.g., 3x5 coin envelop) and complete the Air Sample Information Form, Attachment 7.3 or equivalent sample label and transport the sample to the counting area.

5.7.10. Assign the air sample a unique air sample ID and enter the pertinent information in the Air Sample Log, Attachment 7.4. The information that should be recorded as part of the air sample on the air sample log includes:

- Air Sample ID and location,
- Employee name for PAMs,
- RWP,
- Work Description,
- HP Technician collecting the sample,
- Date and time on,
- Date and time off,
- Air sampler flow rate (initial and post)
- Air Sampler serial number or ID,
- Air sampler calibration date

5.7.11. For heavily loaded air samples, (e.g., laden with concrete dust) ensure all material on the filter is collected for analysis purposes.

5.8. Air Sample Analysis

5.8.1. Select a counting method and system and establish count times such that the radionuclides of concern can be detected with appropriate detection sensitivities in accordance with Section 5.9.

5.8.2. Establish an instrument background count time based on the MDC requirements and obtain background readings with a clean planchet and air sample filter. Typical background counting times range from 10 to 60 minutes.

5.8.3. Place the air sample on a clean planchet and insert the sample into the counting instrument with the collection side facing the detector. Tweezers should be used when handling the air sample media to avoid any potential cross-contamination and to avoid direct handling of the collection area on the filter.

5.8.4. Minimize any handling of the filter in order to maintain the integrity of the sample and to prevent any loss of build-up on the filter.

5.8.5. Depending on the sample loading and the emission energies of the primary radionuclides of concern, assign a self-adsorption (SA) factor for sample analysis. The self-adsorption factor is the percent of emissions that are attenuated by the sample and the sample media itself and are not incident with the detector. The amount of self-adsorption will decrease with higher emission energy and lower filter loading. For typical air samples, the SA is negligible; however, the following guidance may be used when assigning SA factors.

5.8.5.1. For alpha emissions and low energy betas with a maximum beta energy of 0.15 MeV or less, use an SA factor of 10% (0.1).

5.8.5.2. For beta energies greater than 0.15 MeV, use an SA factor of 0%.

5.8.5.3. For heavy filter loading where self-adsorption is of concern, such as concrete dust, SA can be significant and an alternate method of analysis may be more appropriate such as gamma spectroscopy, alpha spec or other volumetric analytical method as directed by the PHP or RSO.

5.8.6. For typical air samples, the entire filter will be counted (i.e., 47 to 52 mm filter); however, for larger sampling media, the sample may have to be cut in order to fit the sample into the counter. If the air sample must be cut, determine the fraction of the sample counted as follows:

$$f_{filter} = \frac{D_o^2}{D_1^2}$$

Where: D_o = Filter diameter as counted
D_1 = Initial filter diameter prior to sizing

5.8.7. Count the sample based on the MDC requirements in Section 5.9. Typical air sample counting times range from 10 to 60 minutes, but this depends on the background counting time, volume of air sampled, the site-specific DAC value and the MDC requirements.

5.8.8. Depending on the decay time of the air sample prior to counting, the results must be scrutinized due to potential interference from the Radon/Thoron progeny, particularly for projects where Radon is an issue. Sample results should be considered preliminary until it is determined that the Radon/Thoron daughters have adequately decayed. Typical decay times required range from 48 to 72 hours in order to minimize any interference from the Radon/Thoron progeny. If results are required sooner, the following may be performed under the direction of the PHP or RSO.

5.8.8.1. A background reference sample may be collected; however, caution should be taken to ensure it is representative of the monitored area as Radon can vary significantly from location to location and time of day due to changing weather such as temperature and low and high pressure fronts.

5.8.8.2. A decay study may be performed to extrapolate and estimate the airborne activity by counting the air sample repeatedly, plotting the results against time and the data curve fitted to extrapolate an estimated air sample activity. The curve should asymptotically approach the actual filter activity on the Radon/Thoron decay is complete.

5.8.9. Calculate the air sample activity in units of μCi/ml using the following equation:

$$A = \frac{R_S - R_B}{f_{filter} \cdot \varepsilon_i \cdot (1 - SA) \cdot V \cdot 2.22E6}$$

Where:

R_S	=	Sample count rate (counts per minute)
R_B	=	Background count rate (counts per minute)
ε_i	=	4π instrument efficiency
SA	=	Self-Adsorption factor (%)
V	=	Sample volume (ml)
f_{filter}	=	Fraction of the filter counted

5.8.10. The air sample volume should be based on the average air sample flow as determined from the recorded air flow at the time the sample was turned on and at the time the sample was turned off.

5.8.11. Document the sample counting information and results on an Air Sample Results / Report, Attachment 7.5 or equivalent.

5.8.12. Determine the DAC fraction as required when using the DAC value(s) as calculated in Section 5.2 as follows:

$$f_{DAC} = \frac{A}{DAC_{(\alpha,\beta)}}$$

5.9. Minimum Detectable Concentration (MDC)

5.9.1. For on-site monitoring of occupational and non-occupational personnel, the detection sensitivity or MDC for air sampling should be at least 10% of the site-specific DAC as determined in Section 5.2, to the maximum extent practical.

5.9.2. For monitoring the general public, i.e. off-site release, the MDC should be at least 50% of the effluent limit or less as determined in accordance with Section 5.2 to the maximum extent practical.

5.9.3. Consider air flow rates and the planned run times in order to maintain reasonable sample counting times during sample analysis and to ensure the proper detection sensitivities based on the type of sampling being performed. The air sample and background counting times may be adjusted accordingly within reason to meet the desired MDCs.

5.9.4. The air sampling MDC[2] shall be calculated as follows depending on the background count rate assuming a Poisson distribution and probabilities of false positive (α, Type I) and false negative (β, Type II) error rates of 0.05 or 5%.

Alpha Counting (low background):

$$MDC_{\alpha} = \frac{\frac{3}{T_S} + 3.29\sqrt{\frac{R_B}{T_S} + \frac{R_B}{T_B}}}{f_{filter} \cdot \varepsilon_i \cdot V \cdot 2.22E6}$$

Beta Counting:

$$MDC_{\beta} = \frac{\frac{2.71}{T_S} + 3.29\sqrt{\frac{R_B}{T_S} + \frac{R_B}{T_B}}}{f_{filter} \cdot \varepsilon_i \cdot V \cdot 2.22E6}$$

Where:
R_B = Background count rate (counts per minute)
T_S = Sample counting time (min)
T_B = Background counting time (min)

[2], Table 3.1, NUREG-1507, Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions, Final Report, December 1997

ε_i = 4π instrument efficiency
SA = Self-Adsorption factor (%)
V = Sample volume (ml)
f_{filter} = Fraction of the filter counted

5.10. Reporting

5.10.1. Report any unanticipated results to the RPS and the PHP or RSO such that any change in conditions may be assessed and to ensure the proper controls have been implemented and submit a first notification in accordance with AE-SH-PR-002, *Incident Reporting and Notification* as applicable.

5.10.2. Report any environmental (i.e., off-site) releases to the general public at site boundaries or any other release point in excess of the effluent limits immediately to the RPS, PHP and RSO such that any appropriate notifications can be made in accordance with NS-RS-PG-001, *Radiation Protection Program*.

5.10.3. Report any results exceeding 0.3 DAC in areas where respiratory protection is not being worn to the RPS and the PHP or RSO.

5.10.4. Report any results exceeding 10 DAC in areas where respiratory protection is being worn to the RPS and the PHP or RSO.

6. Records

6.1. DAC or Effluent Limit Evaluation

6.2. Air Sampling Location Summary and/or Map

6.3. Air Sampling Information Form or equivalent Sample Label

6.4. Air Sampling Log

6.5. Air Sample Result Report

7. Appendices and Forms

7.1. DAC / Effluent Limit Evaluation

7.2. Air Sample Location Summary

7.3. Air Sample Information Form

7.4. Air Sample Log

7.5. Air Sample Results / Report

Attachment 7.1 DAC / Effluent Limit Evaluation

						10CFR20 Appendix B - Table 2				Perimeter
		Relative				Occupational	Effluent	Occupational	Occupcational	Effluent
Radionuclide	Class	Fraction	Decay Mode	Yield	Detectable	DAC			Non-Rad	
		f_i	(α / β)		(y / n)	uCi/ml	uCi/ml	f_i / DAC_i		f_i / C_i
							Σ	0.00E+00	0.00E+00	0.00E+00
							1 / Σ	#DIV/0!	#DIV/0!	#DIV/0!
							f_α			
							α-Limit	#DIV/0!	#DIV/0!	#DIV/0!
							f_β			
							β-Limit	#DIV/0!	#DIV/0!	#DIV/0!

Attachment 7.2 **Air Sample Location Summary**

A/S Location	Sample Type [a]	Applicable Limit [b]

a Sample type includes: (Site Boundary, Area Perimeter, Control Point, General Area, Breathing Zone, etc.)
b The applicable monitoring limits include occupational, non-occupational or environmental/public

Attachment 7.3 **Air Sample Information Form**

A/S ID		**RWP**	
Work Description			
Location			
Initial Flow Rate		**Ending Flow Rate:**	
Air Sampler Model		**Air Sampler ID**	
Cal Due Date		**Type of Sample** [a]	

a Breathing Zone (BZ), Occupational G/A, Perimeter, Site effluent

Cycle	Date On	Time On	Date Off	Time Off
1				
2				
3				
4				
5				
6				

Technician: _____ Date: _____

Attachment 7.4 **Air Sample Log**

A/S ID (Number)	Description	Location	RWP	Collection Date	Air Sampler Info	
					Model	ID

Attachment 7.5 **Air Sample Results / Report**

AIR SAMPLE ANALYSIS SHEET

Sample Number:

General Information			
RWP #:		Sampler Type:	
Technician:		Serial Number:	
Location:		Calibration Date:	
Work Descrip:		Job Type:	

Sample Information							
Flow Rate (lpm = cfm*28.3)		Date On	Time On	Date Off	Time Off	Duration	Volume
Start	End		(HH:MM)		(HH:MM)	(minutes)	(cc)

Instrument Information							
	Analysis Date	Instrument Model	Instrument Serial Num.	Calibration Due Date	Bkg CT (minutes)	Sample CT (minutes)	Efficiency (cpm)
Alpha							
Beta							

Results							
	Sample		Background		Net Rate	MDA	Activity
	(gross counts)	(cpm)	(gross counts)	(cpm)	(cpm)	(uCi/ml)	(uCi/ml)
Alpha							
Beta							

Report					
	Isotope	Limit (uCi/ml)	Fraction No Self-Absorption (SA)	SA Factor[1] Cross. [illegible]	Adjusted Fraction Corrected for SA
Alpha					
Beta					

Further Analyses Required	
Analysis Requested	Results (Lab ID, Cross Reference)

Review
Samples with DAC Fractions greater than 0.25 must be reported to the CHP or PM at once.
Performed by / Date:
Reviewed by / Date: