1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide the methods for sampling airborne radionuclides within the Processing Plant (Plant) at the Lost Creek ISR (LC-ISR) site. Air sampling is used to determine the potential radiological internal dose due to inhalation for persons in the Plant pursuant to 10 CFR 20.1204, 10 CFR 20 Subpart F (20.1501-1502), and NRC License Condition 10.15. Air sampling allows determination if the concentrations of radionuclides could contribute to an excess of 10% of the Annual Limit of Intake (ALI). Sampling of airborne radionuclides helps to determine if engineering controls are effective in protecting workers from inhalation exposure. Determination of potential inhalation exposure works in conjunction with bioassay monitoring (SOP_LC_HP-009: *Bioassay Monitoring*) to determine actual intakes.

2.0 RESPONSIBILITIES

The RSO is responsible for the following topics, but may assign specific tasks to the HPT or Designee.

- Protecting workers from exposures due to air particulate radionuclides;
- Measuring the airborne radionuclides as detailed in this SOP;
- Determining the DAC or ALI values for the Plant for appropriate radionuclides;
- Maintaining air sampling data and records for the life of the license;
- Providing training for the proper operation of air sampling equipment and proper sampling locations;
- Posting airborne radioactivity areas with conspicuous signage;
- Maintaining and calibrating equipment for this SOP.

The HPT will take on the RSO's responsibilities as assigned or when the RSO is not present. The RSO will be responsible for ensuring tasks and responsibilities were completed in the RSO's absence.

3.0 PREREQUISITES AND TRAINING

An air sampler that is properly maintained and calibrated according to the manufacturer's instruction shall be used for air sampling.

Training of EHS personnel includes reading and understanding this SOP and the manufacturer's procedures with a practical demonstration of proper operation under the supervision of the RSO or HPT.

4.0 DEFINITIONS

Airborne radioactivity area: A room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist or may exist in concentrations:

(1) In excess of the derived air concentrations (DACs) specified in Appendix B, to §§20.1001–20.2401, or

(2) To such a degree that an individual present in the area without respiratory protective 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.

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 value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) or a committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue. (ALI values for intake by ingestion and by inhalation of selected radionuclides are given in table 1, columns 1 and 2, of appendix B to §§20.1001–20.2401).

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 under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in table 1, column 3, of appendix B to §§20.1001–20.2401.

Derived Air Concentration-Hour (DAC-hour): 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. A licensee may take 2,000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 5 rems (0.05 Sv).

LLD (Lower Limit of Detection): The smallest concentration of radioactive material that has a 95% probability of being detected by an instrument.

5.0 HAZARD ASSESSMENT AND PPE

Persons who perform air sampling should always be mindful of the potential hazards of working in the Plant which may include:

- Wet floors and tripping hazards
- Equipment and overhead obstructions
- Elevated levels of radiation in restricted areas (radiation areas)
- Chemicals in chemical storage areas
- Radon and uranium particulates in certain areas
- Other occupational hazards described in applicable SOPs

Personal Protective Equipment (PPE) that shall be worn during sampling includes:

- Standard required Plant PPE:
  - Hard hat;
  - Safety eyewear; and
  - Safety footwear.
- Additional PPE may include:
  - Disposable gloves (e.g. nitrile);

PPE required when entering an airborne radioactivity area includes:

- Respirator
- (optional) Coveralls, such as Tyvek®
- (optional) Disposable gloves (e.g. nitrile)

6.0 PROCEDURE

The procedures in the following sections describe the method for measuring airborne radionuclide concentrations at various locations within the Plant described in TR Section 5.7.3.1. The locations and frequencies are provided in the following table:

TABLE 6-1: Sampling Summary

Area	Frequency	Duration
Yellowcake slurry storage tank	Monthly	30 min (or longer as needed to meet applicable LLDs – see Section 6.4)
Filter press	Monthly	
Yellowcake dryer room	Weekly	
Yellowcake drum storage area	Monthly	

Airborne radionuclide samples will be taken at locations shown on TR Figure 5.7-1 (included at the end of this SOP). The sampling locations depicted are subject to change based on the characteristics of the Plant and considerations such as the air flow through the Plant and best location for measuring exposure to workers. A sampler will be set up and operated for durations to meet the LLD of the radionuclide as described in Section 6.1 below.

Grab samples for uranium should be taken weekly in airborne radioactivity areas if workers occupy the area and monthly in areas not designated as airborne radioactivity areas.

Analysis will include other radionuclides (Ra-226, Th-230, Pb-210, and Po-210) on a semi-annual for the first 2 years and annual basis after that to determine if sampling for other radionuclides is necessary.

Monitoring for air particulates in an individual's breathing zone is discussed in SOP_LC_HP-017: *Breathing Zone Air Monitoring.*

6.1 Sample Collection

The primary air sampler is the F&J model DF-40L-8, and the primary filters used are the glass fiber filter papers supplied by F&J Specialty Products. Other samplers, such as the Bladewerx SabreAlert², F&J model L-12P personnel pump, or other equivalent device may be used if necessary as long as the LLD requirements are satisfied. Other filter media may be used as necessary, such as one of the following types: glass fiber, cellulose, acetate, or Speclon™ PTFE (recommended by Bladewerx). Sampling

equipment shall be operated according to manufacturer's procedures as described in the Operator's Manual.

See the appropriate SOP and operator manuals for use of air samplers. The DF-40L-8 operation is explained in SOP-LC-ENV-005 – *Air Sampler Filter Change*. The typical sample set up is as follows:

Flow Rate: 30 L/min

Sample Time: at least 30 minutes

If other sample numbers are used then calculate the LLD to ensure the requirements listed in section 6.4.1 are met for the nuclides of interest. To calculate the LLD use the following equation:

$$LLD = \frac{2.71 + 3.29\sqrt{R_b t_s\left[1 + \frac{t_s}{t_b}\right]}}{(t_s)(E_d)(E_f)(FF)(SAF)(Vol_{cc})(2.22E6)}$$

LLD = lower limit of detection in µCi/ml
R_b = background count rate in cpm
t_s = sample counting time in minutes
t_b = background counting time in minutes
E_d = detector efficiency in counts per disintegration
E_f = filter efficiency
FF = fraction of filter counted
SAF = self absorption factor
Vol_{cc} = air sample volume in cc (or ml)
2.22E6 = factor to convert dpm to µCi

As applicable, a conservative filter self-absorption correction factor of 0.5 will be applied.

Air Sample Equation:

$$V = \frac{F}{t_{sample}} \times \frac{1000ml}{1L}$$

V = *Volume (ml)*
F = *Flow rate (L/min)*

Once a filter sample is collected:

1. Carefully remove filter from filter housing with tweezers or other appropriate device.
2. Place filter in a sample container (envelope or Ziploc bag).
3. Label container with date, time, sample ID, sample duration, sample volume (if applicable), and sampler ID.

6.2 Sample Analysis

Filters will be analyzed routinely for U-nat for the monthly and weekly events by measuring the gross alpha count and assuming U-nat is the significant contributor.

1. Wait 24 hours (this number is conservative and subject to change) to ensure radon progeny have decayed. A preliminary measurement is acceptable to estimate the alpha nuclide airborne concentration, but then the sample should be recounted after waiting the appropriate amount of time.
2. When counting the filter, carefully remove the filter from the sample container with tweezers or other appropriate device.
3. Place filter on a planchette with the sampling face of the filter up, and place planchette in the counting tray in the Alpha/Beta counter.
4. Count the sample for 10 minutes. If shorter count times are used, then recalculate the LLD and compare to the requirements listed in section 6.4.1.
5. Carefully return sample filter to the zip-seal bag if the sample is going to be sent to a contracted lab.
6. Perform a background count for the same amount of time.

Radiation Measurement Equation:

$$A = \frac{C_{rad} E\, k_{units}}{t_{count}}$$

A = *Sample Activity (uCi)*
C_{rad} = *Counts*
t_{count} = *Measurement Count time (min)*
t_{count} = *Measurement Count time (min)*
E = *Instrument Efficiency (cpm/dpm)*
K_{units} = *conversion factor (4.5x10-7 uCi/dpm)*

Concentration Equation:

$$C = \frac{A}{V}$$

C = *Concentration of Nuclide (uCi/ml)*

Filters will be analyzed by a contracted lab, such as EnergyLab or IML, for isotopic analysis semi-annually for the first two years of operation and annually thereafter to demonstrate that the only source of alpha-emitting radionuclides is likely from U-nat. The samples will be analyzed for:

- U-nat
- Th-230
- Ra-226
- Po-210 and
- Pb-210

The isotopic analyses of air samples will be evaluated to ensure that the radionuclides other than U-nat do not contribute more than 10% of the dose from airborne radionuclides, calculated based on the table of radionuclide limits below. If they do exceed this fraction, than the applicable DAC value will have to be reconsidered.

TABLE 6-2: Radionuclide Limits

Radionuclide	ALI (µCi)	DAC (µCi/mL)
Unat (W)	8E-1	3E-10
Th-230 (W)	6E-3	3E-12
Ra-226	6E-1	3E-10
Po-210	6E-1	3E-10
Pb-210	2E-1	1E-10

For all types of air sampling at the plant, concentrations should be determined to be less than 10% of the ALI. If the ALI values are greater than 10%, the area shall be posted as an airborne radioactivity area and/or an ALARA investigation should occur as described in Section 6.5.5. Findings and corrective actions shall be described in the Annual ALARA/RPP Report.

6.3 Chemical Toxicity Limit

To ensure the exposure of workers is less than 10mg/week of soluble uranium (10 CFR 20.1201 (e)), the DAC for this limit is 0.2 mg/m^3 (1.35 E-10 uCi/ml). If the sample concentration of airborne uranium exceeds 10% of this DAC, then the causes will be investigated. Also, the location that the air sample exceeded 10% of this limit will be sampled weekly until 2 consecutive weeks below 10%.

6.4 Airborne Radioactivity Areas

Upon review of the air sample data, areas will be designated as airborne radioactivity areas, if necessary. An area will be posted with conspicuous signage if:

- the DAC values of analytes exceed the DAC limits provided in the table above; or
- the activity of analytes could contribute to 0.6% of the ALI or 12-DAC hours of exposure in one week (column 3 below) to an individual not utilizing respiratory protection.

TABLE 6-3: ALI Values

Radionuclide	ALI (µCi)	ALI x 0.6% (µCi)
Unat (W)	0.8	0.0048
Th-230 (W)	0.006	0.000036 (3.6×10^{-5})
Ra-226	0.6	0.0036
Po-210 (W)	0.6	0.0036
Pb-210	0.2	0.0012

The areas will be posted with a sign or banner such as:

6.5 Quality Assurance/Quality Control/ALARA

6.5.1 Data Objectives

The data set generated from airborne radionuclide sampling includes concentrations of radionuclides in air for the isotopes listed in Section 6.2. The quantity of air sampled and the method of analysis should allow the following lower limits of detection:

TABLE 6-4: LLD Values

Nuclide	LLD (10% of DAC)
U-nat	1×10^{-11}
Th-230	3×10^{-13}
Ra-226	3×10^{-11}
Po-210	3×10^{-11}
Pb-210	1×10^{-11}

Therefore, the sample volume and sample count time are determined from the LLD equation provided in SOP_LC_HP-004: *Instrument Calibration*.

6.5.2 Measurement Quality Control

Blank filter samples shall be analyzed along with the batch. During indoor Plant characterization, a long term background sample shall be taken in an area that is free of air particulate contamination such as the Health Physics lab or an office to aid in the determination of LLD.

6.5.3 Calibration

Air samplers should be calibrated according to manufacturer's specifications and procedures described in the Operations Manual (SOP_LC_ENV-006-*Air Sampler Maintenance &* Calibration). Air samplers will be calibrated semi-annually, or per manufacturer's recommendation (TR 5.7.3.1).

Radiation detection instrumentation will be calibrated and maintained according to SOP_LC_HP-004-*Radiation Detection Instrumentation*.

6.5.4 Data Verification and Validation

Data will be reviewed by the health physics individual taking the sample and calculating the radionuclide concentrations to determine if the numbers are reasonable and within expected ranges. The data may be charted for comparison to visually reveal trends or to determine if the data is consistent. The RSO will review the control charts and calculations to validate the data.

6.5.5 Audits/Corrective Actions/ALARA

To ensure dose to workers is accurately determined, the sampling will be compared with other results including:

- comparing with bioassay results
- comparing with BZ measurements

If the results are not comparable, corrective action may need to be taken depending on the situation.

Air sampling procedures and results shall be reviewed at least annually in conjunction with Radiation Protection Program/ALARA audits and reviews. The following elements taken from RG 4.25 may be included in the review:

- *Purposes and amount of air sampling:* Was the air sampling appropriate for the intended purposes? Was there too much or too little air sampling done?
- *Location of Sampling:* Were fixed-location air samplers located properly? Were grab samples taken with proper regard to airflow patterns?
- *Trends:* Do trends in air sampling results and worker intakes indicate that confinement of radioactive materials remains adequate?
- Were prospective estimates of intake reasonably accurate?
- *Posting:* Is the posting of airborne radioactivity areas appropriate?
- *Procedures:* Are written procedures still suitable and up to date?
- *Adjustment of DACs:* Were DACs adjusted for particle size or solubility? If so, are the original adjustment factors still valid?

- *Correction factors:* Were correction factors applied to air samples to determine worker intakes? If so, are the correction factors still valid?
- *False alarms:* Was continuous air monitoring done? If so, did excessive false alarms occur?
- *Representativeness:* For air sampling done to determine significant intakes, was the representativeness demonstrated to be adequate?
- *Changes:* Have changes in air sampling procedures or equipment occurred that could affect the quality of the measurements?
- Have changes in the facility operation or equipment occurred that could affect the quality of air sampling measurements?

7.0 DOCUMENTS AND RECORDS

Calibration documents shall be maintained until license termination and in a form compliant with NRC RG 8.7 (per TR 5.7.3.1). Documents and records related to air particulate sampling will include:

- Instrument calibration records
- Instrument Operator's Manual
- Laboratory data
- DAC calculations
- ALARA/RPP reports

8.0 REFERENCES

Code of Federal Regulation Title 10 Part 20: *Standards for Protection Against Radiation*

NRC License Amendment, *Vacuum Dryer Amendment Supplement to the Lost Creek ISR, LLC Technical and Environmental Reports*, January 2012

NRC License Application Technical Report, Section 5.7.3: *In-Plant Airborne Radiation Monitoring Program*, April 2010

NRC License Application Technical Report, Figure 5.7-1: *Locations of In-Plant Radiological Sampling*, January 2012

NRC License Condition 10.15

NRC, Regulatory Guide 8.25: *Air Sampling in the Workplace*, June 1992

NRC, Regulatory Guide 8.30: *Health Physics Surveys in Uranium Recovery Facilities,* May 2002

SOP_LC_HP-004: *Instrument Calibration*

SOP_LC_HP-009: *Bioassay Monitoring*

SOP_LC_HP-017: *Breathing Zone Air Monitoring*

MAP OF SAMPLING LOCATIONS