	UR-ENERGY USA, INC. LOST CREEK ISR, LLC STANDARD OPERATING PROCEDURE	
DETERMINING DOSE OF UNMONITORED EMPLOYEES		
Edition: 10Jul2013	**SOP Number:** SOP_LC_HP-019	**Author:** CJP

Reviewed By: JWC 7/07/2013; CTK 7/9/2013	***Final Approval:*** CHARLES KELSEY Digitally signed by CHARLES KELSEY DN: cn=CHARLES KELSEY, o=LOST CREEK ISR, ou=UR-ENERGYUSA, email=charles.kelsey@ur-energyusa.com, c=US Date: 2013.07.17 13:31:38 -06'00'

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to establish the method by which Lost Creek ISR (LC-ISR) Project will validate that the external and internal radiation doses to unmonitored employees will be less than 10% of the 10CFR20 occupational dose limits for radiation workers. Not all of the step-by-step procedures for sampling are included in this SOP, but the pertinent sampling SOPs are referenced.

Most of the employees working at the LC site will be monitored in some way. Those working in the plant routinely will be part of the most detailed monitoring. The monitoring of employees outside the plant is covered by a combination of environmental monitoring stations and representative thermoluminescent dosimeter (TLD) or equivalent badges. There are environmental monitoring stations located around the LC site which ensure the effluent concentrations are within acceptable limits (SOPs ENV- 4, 13, and 14). Dose from external radiation will be monitored by having representative employees from each work type wearing TLD badges (covered by SOP HP- 2). As long as the doses to the representative employees are below 10% of the limit then it is reasonable to expect the dose from other employees performing the same tasks will be below the limits.

2.0 RESPONSIBILITIES

The Radiation Safety Officer (RSO) and/or Health Physics Technician (HPT) are responsible for:

- Performing sampling outlined and referenced in this SOP
- Writing a report detailing the likely dose to unmonitored employees based on the sampling outlined in this SOP.

3.0 PREREQUISITES AND TRAINING

The person performing the dose assessments should be familiar with the facility and health physics principals relevant for determining dose.

4.0 DEFINITIONS

Annual Limit of Intake (ALI): derived limit for amount of radiation through ingestion or inhalation. These limits can be found in 10 CFR 20 Appendix B

As Low as Reasonably Achievable (ALARA): maintaining occupational doses and doses to members of the public as low as is reasonably achievable using, to the extent practical, procedures and engineering controls based upon sound radiation protection principles.

CDE (Comitted Dose Equivalent): The dose equivalent to organs or tissues of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

CEDE (Comitted Effective Dose Equivalent): 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.

DDE (Deep Dose Equivalent): External whole-body exposure dose equivalent at a tissue depth of 1 cm (1000 mg/cm^2).

EDE (Effective Dose Equivalent): The sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma W_T H_T$).

Roentgen Equivalent Man (rem): the special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem=0.01 sievert).

Sievert (Sv): the SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv=100 rems).

TEDE (Total Effective Dose Equivalent): The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Working level (WL): "is any combination of short-lived radon daughters (for radon-222: polonium-218, lead-214, bismuth- 214, and polonium-214; and for radon-220: polonium-216, lead-212, bismuth- 212, and polonium-212) in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha particle energy." (10CFR20)

Working level month (WLM): "means an exposure to 1 working level for 170 hours (2,000 working hours per year/12 months per year=approximately 170 hours per month)." (10CFR20)

5.0 HAZARD ASSESSMENT AND PPE

N/A

6.0 PROCEDURE

The total radiation dose to an individual is comprised of an external dose and an internal dose. A representative external dose will be determined from area monitoring TLDs placed to measure exposure to unmonitored employees. Internal dose at LC-ISR is attributed to intake of process emissions of radon/radon progeny and other airborne particulate natural uranium decay chain radionuclides. Landauer Radtrak radon samplers, or other similar devices as approved by the RSO, will be used as quarterly area monitors for determining representative internal doses due to radon. Kusnetz method sampling will be used to determine dose from radon progeny. Potential presence of particulate U-nat will be sampled by collection on glass fiber filters and measured with alpha/beta detectors. Dose will be estimated by the following equation:

$$TEDE = CEDE + DDE$$

Where:
DDE is the dose from the office TLD results in rem (see section 6.1)

CEDE is the internal dose, in rem, based on radon measurements (see section 6.2) and airborne particulate sampling (see section 6.3)

6.1 External Exposure

TLD or equivalent dosimeters will be located in representative areas in the plant offices (Appendix) to validate that unmonitored employees do not receive more than 10 percent of the limits provided in 10 CFR 20, Subpart C. The TLDs will be exchanged quarterly. The dose rates from these monitors should represent worst-case scenario for likely doses to office personnel. To account for time workers actually spend in the office, an occupancy factor of 0.25 will be applied to the TLD results (based on the typical 2,000 hours spent at work in a year).

Some employees who do not work in the plant, and who do not work in the office, will not be badges. To ensure these individuals are receiving doses below 10% of the limit representative workers from each work crew will wear badges. Details of this are explained in section 6.3 of SOP_LC_HP-002_*Personnel External Radiation Dosimetry*.

Spare badges may be assigned to employees that do not typically wear badges, if they are going to be doing work in the plant, or other area with increased external radiation dose rates. Giving an individual a spare badge will depend on the activity, duration, frequency and the location to be occupied.

6.2 Radon and Radon Progeny

The sampling locations (Appendix) for air particulates, radon, and progeny are located to assess the distribution of airborne radionuclides. Sampling will be performed in the foyer connecting the plant to the offices. If contamination is present in the office, then it should be present in this area. Sampling will also be performed in the lab, because lab personnel handle samples from the plant area. Sampling will be performed in the secretary's office by the office front entrance, and in a first floor office down one of the hallways. The concentration of airborne radionuclides is expected to be less in the second floor offices, because this area is further away from the entrance to the office area. Second floor office sampling will be performed near the hallway entrance to the conference room.

Sampling will be performed for the first year of operations. The sampling will be used to demonstrate which employees are likely to receive less than 10% of the annual dose limit.

Two sampling methods will be used to determine the radon and radon progeny dose to employees working in the offices. Radtraks will be used to measure Rn-222. Radon progeny will be measured with the Kusnetz method.

Radon dose to employees working outside the CPP building are monitored by default, because the effluent from the plant must also meet the limits for members of the public.

6.2.1 Radtrak Results

The Radtraks will measure the levels of Rn-222 in the office. Radon concentration measurements can give a reasonable approximation of the concentration of radon progeny, but the radon progeny will be measured based on the Kusnetz sampling method (section 6.2.2). Radtrak results will be compared to the conservative DAC for Rn-222 (3×10^{-8} uCi/ml) to determine potential for exceeding 10% of the dose due to radon gas when daughters are present at some level of equilibrium. Given that a typical employee works 2000 hours in a year, an employee exposed to an average concentration equivalent to the DAC would result in a 5 rem dose. This ratio (DAC/5rem) can be used to determine the dose contribution from radon progeny to the TEDE.

Radtraks will be quarter long sampling periods. Sampling locations are shown in the appendix.

6.2.2 Kusnetz Results

The Kusnetz method is detailed in SOP_LC_HP-005_*Radon Monitoring and Mitigation.* The results of this procedure are given in Working Levels (WL). The WL is a measure of the radon progeny dose. This is compared to the DAC for Rn-222 with progeny present (0.33 WL). Given that a typical employee works 2000 hours in a year, a 0.33 WL concentration would result in the equivalent of 5 rem dose. This ration (0.33WL/5rem) can be used to determine the dose contribution from radon progeny to the TEDE.

Kusnetz air sampling will be at least 1 time every 2 weeks for the first 6 months of operation. If the results of the sampling show the radon progeny concentrations are at a steady state comparable to normal site quarterly fluxuations, then sample frequency will be reduced to 1 time every month. Sampling locations are shown in the appendix.

6.3 Airborne Radionuclides

Air samples will be collected on glass fiber filters to analyze the concentration of uranium decay chain radionuclides in the air. Only U-nat will be considered part of the measurement from the air sample unless the semi-annual plant characterization indicates other radionuclides of concern (see section 6.2 of SOP_LC_HP-008_*Indoor Airborne Radionuclide Sampling*). The method for sampling and analyzing the samples is detailed in SOP_LC_HP-008_*Indoor Airborne Radionuclide Sampling*.

Sampling will be at least 1 time every 2 weeks for the first 6 months of operation. If the results of the sampling show the uranium concentrations are steadily below 10 percent of occupational limits, then sample frequency will be reduced to 1 time every month. Sampling locations are shown on the figure in the Appendix.

Airborne radionuclide dose to employees working outside the CPP building are monitored by default as less than 10 percent of the occupational dose, because the effluent from the plant must also meet the limits for members of the public.

7.0 DOCUMENTS AND RECORDS

The results of the sampling performed for this procedure will be analyzed by the HP staff to determine necessary occupational dose monitoring. The results of monitoring analysis will be reported in the annual Radiation Protection Program Report .

8.0 REFERENCES

Code of Federal Regulation Title 10 Part 20 Appendix B: *Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure*

NRC, Regulatory Guide 8.34: *Monitoring Criteria and Methods to Calculate Occupational Radiation Doses*, July 1992

NRC License Technical Report, Section 2.9.3.1: *Supplementary MILDOS Modeling*

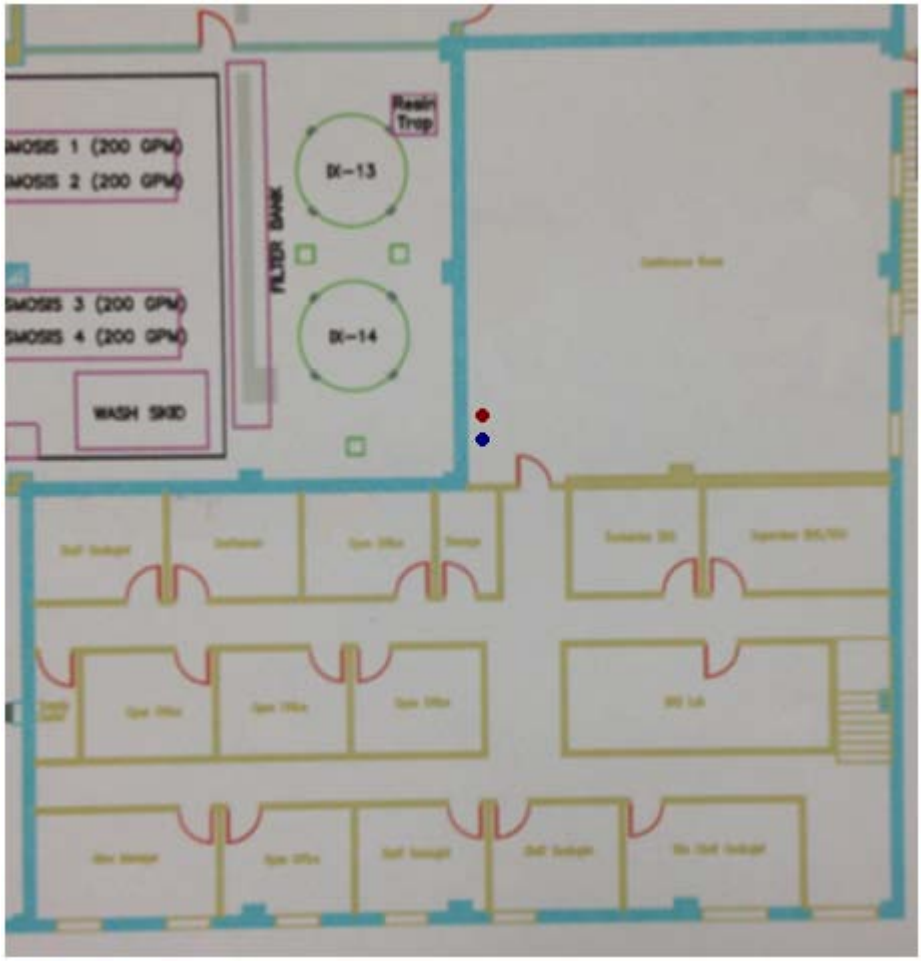
NRC License Technical Report, Section 5.7.4: *Worker Dose Calculations*

Appendix: Sampling Locations in Office Area

1st Floor

- TLD
- Radtrak/Kusnetz
- Airborne Radionuclides

2nd Floor



- TLD
- Radtrak/Kusnetz
- Airborne Radionuclides