
	UR-ENERGY USA, INC. LOST CREEK ISR, LLC STANDARD OPERATING PROCEDURE	
<b>PERSONNEL EXTERNAL RADIATION DOSIMETRY</b>		
<b>Edition:</b> 12July2013 Rev1	<b>SOP Number:</b> SOP_LC_HP-002	<b>Author:</b> CJP
<b>Reviewed By:</b> CTK 4/9/2012; MDG 7/30/2012; JWC 2/15/2013; MDG 3/1/2013; MDG 6/6/2013; CTK 6/12/2013		<b>Final Approval:</b>

## 1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide the process for monitoring external radiation exposures of personnel working at the Lost Creek ISR (LC-ISR) project. Personal dosimeters (or “badges”), such as Thermoluminescent Dosimeters (TLD) or equivalent, will be used for monitoring doses due to external ionizing radiation. Workers’ external doses are monitored to ensure that exposures are limited in accordance with the principle of ALARA and that occupational dose limits are not exceeded. This SOP is pursuant to the dose limits provided in 10 CFR Part 20, Subpart C.

Additionally, this SOP describes how LC-ISR will ensure that unmonitored employees will not exceed 10 percent of the dose limits provided in 10 CFR Part 20, Subpart C. Also, this SOP describes the management of dosimeters, record keeping requirements in accordance with 10 CFR 20.2106, and the periodic ALARA evaluation of the dosimetry program.



## 2.0 RESPONSIBILITIES

The RSO and/or HPT is responsible for:

- Providing dosimeters for dose monitoring of employees
- Providing employees a confidential report of annual occupational dose
- Maintaining dosimeter data and dose records
- Ensuring unmonitored employees do not receive more than 10 percent of the dose limits provided in 10 CFR Part 20, Subpart C
- Ensuring dosimeters are worn in restricted areas
- Ensuring dosimeters are being worn properly
- Periodic review of dose data to improve ALARA as practicable

Workers are responsible for:

- Wearing the badge in an appropriate location on the body in order to measure representative doses.
- Performing duties consistent with ALARA philosophy
- Securing badges properly in storage when not worn.

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### 3.0 PREREQUISITES AND TRAINING



Dosimeters shall be procured from a vendor accredited through the National Voluntary Laboratory Accreditation Program (NVLAP). Any lab used to analyze the dosimeters from the LC-ISR project shall be NVLAP-accredited.

The following are conditions when badges are required:

- Adults likely to receive, in one year from sources external to the body, a dose in excess of ten percent of the dose limits provided in 10 CFR Part 20, Subpart C, § 20.1201(a);
- Minors likely to receive, in one year, from radiation sources external to the body, a deep dose equivalent in excess of 0.1 roentgen equivalent in man (rem) (one millisievert [mSv]), a lens dose equivalent in excess of 0.15 rem (1.5 mSv), or a shallow dose equivalent to the skin or to the extremities in excess of 0.5 rem (five mSv);
- Declared pregnant women likely to receive during the entire pregnancy, from radiation sources external to the body, a deep dose equivalent in excess of 0.1 rem (one mSv);
- Individuals entering a high or very high radiation area; or
- At the discretion of the Radiation Safety Officer (RSO), for example, when unlikely accidental external exposures are possible, and to assist in maintaining doses at levels ALARA.

The following categories of personnel working at the LC-ISR project will generally be issued dosimeters as part of the Dosimetry Program:

- Site supervisors
- On-site EHS staff
- Plant operators including dryer operators
- Plant engineers
- A representative individual from:
  - Maintenance crew
  - Casing crew
  - Construction crew
  - On site geology department
- A representative sample of wellfield operators

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- Others at the discretion of the RSO or Health Physics Technician (HPT)
- Area dosimeters to validate that unmonitored employees do not receive more than 10 percent of dose limits provided in 10 CFR Part 20, Subpart C

Personnel required to wear badges will be required to receive Radiation Safety Training associated with the Radiation Protection Program (RPP) and will be instructed on the proper use of radiation badges. Prenatal exposure consideration is also addressed in the RPP.

Training for dosimetry administrators includes familiarization with this procedure, and completion of a field demonstration under the direct supervision of the RSO or other qualified person that understands and follows this procedure.

#### 4.0 DEFINITIONS



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 (committed dose equivalent): The CDE ( $H_T, 50$ ) is the dose equivalent to organs or tissue of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

CEDE (committed effective dose equivalent): The CEDE ( $H_E, 50$ ) is 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 equivalents for each of the body organs or tissues that are irradiated multiplied by the weighting factors ( $W_T$ ) applicable to each of those organs or tissues ( $H_E, 50 = \sum W_T H_T, 50$ ).

Control badge: The sample control placed in the badge storage area for determining background or ambient radiation effects on the storage and shipping of badges.

DDE (deep-dose equivalent,  $H_d$ ): The external whole-body exposure dose equivalent at a tissue depth of 1 cm (1000 mg/cm<sup>2</sup>).

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Dose equivalent (H<sub>T</sub>): The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

Dosimeter: A small portable instrument (such as a film badge, thermoluminescent dosimeter, or pocket dosimeter) used to measure and record the total accumulated personal dose of ionizing radiation.

Gray (Gy): The SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 Joule/kilogram (100 rads).

LDE (lens-dose equivalent): The external exposure dose equivalent to the lens of the eye at a tissue depth of 0.3 centimeters (300 mg/cm<sup>2</sup>).

NVLAP: The National Voluntary Laboratory Accreditation Program administered by the National Institute of Standards and Technology (NIST) provides third-party accreditation to testing and calibration laboratories.



rad (Radiation Absorbed Dose): The special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram or 0.01 joule/kilogram (0.01 gray).

rem (Roentgen Equivalent Man): 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).

SDE (shallow-dose equivalent, H<sub>s</sub>): The external exposure dose equivalent to the skin of the whole body or the skin of an extremity at a tissue depth of 0.007 centimeters (7 mg/cm<sup>2</sup>) averaged over an area of 1 square centimeter.

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).

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TLD (thermoluminescent dosimeter): Measures ionizing radiation exposure by measuring the amount of visible light emitted from a crystal in the detector when the crystal is heated.

## 5.0 HAZARD ASSESSMENT AND PPE

Hazards and PPE will depend on the specific task performed. Wearing a dosimeter does not cause risk to workers.

## 6.0 PROCEDURE



Personal dosimeters are used to ensure compliance with external exposure limits for workers through routine occupational dose monitoring. Area dosimeters will be posted to determine potential dose for individuals who do not wear personal badges to validate the likelihood they will not receive a dose in excess of 10 percent of the limit. External occupational dose measurements will contribute to the overall dose calculation of the individual's TEDE and will be used to demonstrate that exposures are below regulatory limits.

Visitors of the plant may be badged if the RSO determines the visitor(s) is likely to receive an external dose in excess of the public dose limit. Alternative methods may be used by the RSO, as long as the visitor will receive less than the limits. One alternative is for the visitor to be escorted by the RSO, and the RSO carries a gamma detector to measure the external exposure rate. Another alternative, is that for visiting groups only select individuals may be assigned badges to measure a representative dose to the visitors.

### 6.1 Routine Occupational Monitoring

All full time personnel (LC-ISR employees and contractor employees) who may work in areas where elevated radiation levels may occur shall wear personal dosimeters that will be exchanged quarterly. Part-time workers and contractor employees who might possibly receive a dose in excess of 10% of the annual occupational dose limit will also be issued personal dosimeters.

1. Dosimeters for the upcoming quarter will be received approximately 3 weeks prior to new quarter.

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2. The dosimeters will be loaded into appropriate badges holders and will be retained in a designated storage location whenever not in occupational use by the LC-ISR personnel. The accessible storage location designated by the RSO shall be situated away from radioactive source materials or excessive heat. The current location for badge storage is in the foyer between the plant and the office area.
3. When the RSO or HPT shall assigns a badge to an employee, the badge number is assigned to that specific employee name.
4. When in use, badges shall be worn on the torso between the waist and the neck.
5. When not in use, badges shall be returned to the storage location.
6. Badges will be collected by the health physics staff and shipped to supplier for testing at the end of each quarter. The new badges will be placed in holders and retained at the designated storage location at that time.
7. Any changes in the dosimeter requirements, such as adding or removing employees from monitoring, will be sent to the supplier, using forms provided by the supplier, so that sufficient dosimeters will be available to meet personnel requirements.
8. The RSO or HPT shall review dosimetry reports upon receipt and place them in the appropriate hard copy and/or electronic file.
9. Results from the dosimetry lab will be stored in the following file folder:

[Dosimetry](#)

10. The lab results used for reporting will be compiled in the following Excel spreadsheet:

[Dosimetry.xls](#)

11. The RSO or HPT shall apply the dose to the individual's TEDE.

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12. If a worker receives a dose greater than background, the RSO shall consider the significance and may perform an investigation to determine the cause and possible methods for lowering the dose rate in accordance with the ALARA principle.

### 6.1.1 Occupational Dose Limits

Results from the TLD dosimeter analysis will provide data on the following types of exposures:

Type of Exposure	10 CFR Part 20 Designation	CEDE Dose Limit
External Dose	Deep Dose Equivalent (DDE)	(a)
Skin Dose	Shallow Dose Equivalent (SDE), Skin of Whole Body	50 rem/year (0.5 Sv/year)
Extremity Dose	Shallow Dose Equivalent (SDE), Maximum Extremity	50 rem/year (0.5 Sv/year)
Eye Dose	Eye Dose Equivalent to Lens of the Eye (LDE)	15 rem/year (0.15 Sv/year)



(a) Included in limits for whole body and individual organs. In the absence of any internal exposure, external dose is limited to 5 rem per year. In the absence of any external exposure, internal exposure is limited to 2000 DAC-hours per year or 1 annual limit on intake (ALI) (50 rem/yr non-stochastic, 5 rem/yr stochastic).

The values obtained as a result of the analysis are included in the overall TEDE calculation as described in SOP\_LC\_HP-016: *Radiation Dose Calculations*. The limit for TEDE is 5 rem/year (0.05 Sv/year).

### 6.1.2 Lost Dosimeter Badges

If an employee loses or misplaces a dosimeter:

1. Lost or misplaced dosimeters must be reported to the RSO, Assistant RSO, or Health Physics Technician (HPT) within two work days. However, personnel requiring badges to perform particular work must not continue performing those duties with potential for exposure without a dosimeter. The date the badge was lost should be recorded, which could be useful information if found again.

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2. A replacement badge will be issued with one of the spare dosimeters and will be documented.
3. It is important, if the dosimeter is found, to reveal the location to the RSO to determine if there may be environmental effects on the badge to account for dose determination. For example, if the dosimeter was left in direct sunlight, near a heat source, or near a radiation source there may be unintended effects that could result in a false positive (see Section 6.6.2).
4. The RSO will calculate the "missed dose" by pro-rating the dose recorded on the replacement badge or extrapolating from measured co-worker doses.

## 6.2 Unbadged Personnel Monitoring

Dose rates for unmonitored individuals who enter certain areas of the project site may be gleaned from the dose rates for monitored individuals. Those dose rates will be reviewed to ensure they do not exceed 10 percent of the dose limit. ALARA corrective actions may be required if any doses approach the 10 percent limit.

Members of a work crew that are not expected to receive greater than 10% of the limit may be represented by a badged employee from that crew. The monitored individual's dose rate will be applied to all of the crew associated with that representative worker.

1 Representative Member of Following Crews will wear a badge, selected by the supervisor of that crew:

Wellfield Operators



Wellfield Maintenance

Construction Crew

Casing Crew

Geologists



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### 6.3 Reporting

Data results will be received on a quarterly basis and the values compiled for the calendar year to generate the annual dose report for each individual employee.

1. RSO will evaluate dose reports against exposure limits and the ALARA program.
2. TEDEs will be calculated annually combining external and internal doses, unless the RSO has reason to suspect that combined external and internal doses might approach an occupational limit. If so, a TEDE will be calculated immediately, and the RSO will implement appropriate reporting and ALARA measures.
3. An annual report of assigned occupational doses received in the previous year must be provided to all individuals. An acknowledgement for the report will be signed by the employee who has received a dose report, to verify individuals have seen their annual dose record.
4. The notifications or reports will be provided to the NRC as necessary in accordance with the applicable conditions detailed in 10 CFR 20 Subpart M.

### 6.4 Assigning Dose



The dose value from the dosimetry reports will be used in the dose determination calculation as described in SOP\_LC\_HP-016: *Radiation Dose Determinations*. The dose data reports typically provide the dose rate as a DDE, LDE, and SDE.

### 6.5 Quality Assurance/Quality Control

#### 6.5.1 Data Objectives

The data that is collected from the dosimeters provides the external dose data received by an individual. The dosimeter should be capable of measuring dose within a minimum range of 10 mrem to 500 rem with an accuracy of at least plus or minus 15 percent. Badges may be capable of detecting within a range of 1 mrem to 1,000 rem based on manufacturer's specifications.

#### 6.5.2 Measurement Quality Control

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Control badges are provided by the vendor to use for background measurements or for control during the shipping of badges. A control badge is placed in the badge storage area and submitted for analysis with the personnel badges. The control badge may reveal any issues with radiation affecting storage or handling of badges.

The proper storage or handling of a dosimeter is important for quality control measures since improper handling may cause false positives to occur. False positives may occur due to such factors as direct sunlight, strong heat sources, radiation sources such as calibration sources, or running a dosimeter through the laundry. ALARA reviews should reveal and address the false positives.

### 6.5.3 Calibration

N/A

### 6.5.4 Data Verification and Validation



Data reports will be reviewed by the health physics staff to ensure the data was properly analyzed and the numbers are reasonable. Data verification is also discussed in SOP\_LC\_AD-008: *Data Management*.

### 6.5.5 Audits/Corrective Actions/ALARA

The data collected using personal dosimetry will be evaluated periodically to determine the continued need for monitoring on an employee-by-employee basis.

Any anomalous results of control badge analysis will be investigated and corrective actions proposed. Investigations will be provided in the Annual Radiation Protection Program Report. Audits are also discussed in SOP\_LC\_AD-007: *Internal Audit and Corrective Action Program*.

Dosimeter data will be reviewed when it is received to determine if any dose above background has occurred. If a dose is received, the RSO will determine its significance and may conduct an ALARA investigation to determine the source of the dose and to determine if the source can be mitigated. The dose data will also be compared to historical data to determine if there are any trends in exposures.

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## 7.0 DOCUMENTS AND RECORDS

The following records or documents will be maintained for the dosimetry program for at least the life of the project:

- Analytical results. Hardcopy results will be stored with the EHS office's records. Digital results/reports will be stored in the following folder:

[Dosimetry](#)

The RSO will retain the confidential dose records for each employee for at least the life of the project.

- Radiation Protection Program reporting. Includes dosimetry results and any corrective actions based on the results.

## 8.0 REFERENCES

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



NRC License Application Technical Report, Section 5.7.2.1: *Personal External Dosimetry*, April 2010

NIST, website, <http://www.nist.gov/nvlap/>

Nuclear Regulatory Commission, RegGuide 8.31: *Information Relevant to Ensuring that Occupational Exposure at Uranium Recovery Facilities will be as Low as is Reasonably Achievable*, May 2002

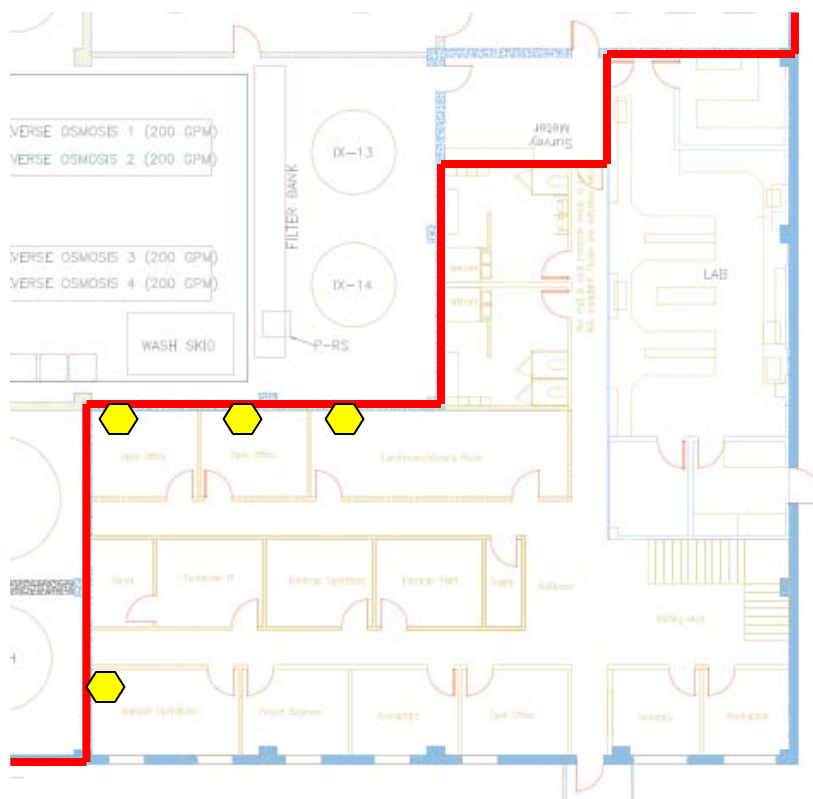
Nuclear Regulatory Commission, NUREG 1569: *Standard Review Plan for In Situ Leach Uranium Extraction License Applications*

SOP\_LC\_HP-016: *Radiation Dose Determinations*

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## APPENDIX: LOCATIONS OF FIXED AREA DOSIMETERS

### Office Area Detail



### Plant Control Room Detail



**Gamma Dosimeter Location**

*Other dosimeters to be placed at locations at the discretion of the RSO.*



**Restricted Area Boundary**