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LOST CREEK ISR, LLC

January 16, 2015

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Re: Reply to NRC's November 3, 2014 Letter Regarding License Condition 12.10
Lost Creek ISR Project License SUA-1598, Docket 040-09068, TAC J00717

Dear Mr. Saxton,

On November 3, 2014 the NRC provided a response to a submittal provided by Lost Creek ISR, LLC ("LCI") nearly 16 months earlier on July 12, 2013. The NRC's response seeks additional information pertaining to how LCI will comply with license condition 12.10 A through B. Toward that end, please find below LCI's proposed plan for NRC's review.

License Condition 12.10
Prior to the preoperational inspection, the licensee shall provide the following information for the airborne effluent and environmental monitoring program in which it shall develop written procedures to:

12.10A Discuss how, in accordance with 10 CFR 40.65, the quantity of the principal radionuclides from all point and diffuse sources will be accounted for in, and verified by, surveys and/or monitoring.

Response:

In order to quantify the principal airborne radionuclides from all point and diffuse sources as required by 10 CFR 40.65, LCI proposes the monitoring program described in attached Table 1 with locations shown in attached Figure 1. This program will include monitoring for the principal radionuclides from all known point and diffuse sources including from the plant, wellfield and header houses. Unless otherwise stated, sampling will occur at the point of discharge or within the confined pipe which leads to the discharge point. This will ensure that the measurements accurately account for the quantity of principal radionuclides being released to the unrestricted area. The concentration of the principal radionuclides will be multiplied by the total volume of air discharged in order to determine the total activity of each principal radionuclide being released to the unrestricted area for each respective reporting period. When multiple measurements are taken, LCI will determine how to integrate the measurements through the reporting time period to ensure the result best fits reality. For example,

NMSS01

the concentration of radon emanating from the precipitation cell vent may vary depending on what stage of operation the system is in. In such cases, LCI will multiply the measured concentration by the volume of air released only during that particular stage of operation.

Plant

The principal airborne radionuclides which may be emitted from the plant are uranium, radon, and radon daughters. This list of primary radionuclides is consistent with Section 2.8.1 of NRC's NUREG/CR6733 "A Baseline Performance-Based Approach for In Situ Uranium Extraction Licensees," 2001, which lists the "normal" airborne releases at an in situ facility to be radon and its daughters and particulates from yellowcake drying and packaging operations. This list of principal radionuclides does not match the list of radionuclides in NRC Reg Guide 4.14 , Revision 1, "Radiological Effluent and Environmental Monitoring at Uranium Mills" which includes three additional radionuclides; radium-226, thorium-230 and lead-210. Reg Guide 4.14 was written specifically for conventional mill facilities which process finely ground bulk ores containing significant quantities of these three radionuclides. These ores and their tailings, at least historically, were occasionally blown into unrestricted areas resulting in the need for soil remediation. In situ mining, on the other hand, brings smaller quantities of these three radionuclides to the surface. Also, thorium-230, radium-226 and lead-210 are not considered principal radionuclides since during most of the process, ion exchange through filtration, these radionuclides are contained in solutions so the opportunity to become airborne effluent is negligible. After the yellowcake is dried these progeny will begin to slowly grow in. However, the time between uranium separation and packaging is generally on the order of 72 hours which is insufficient to allow significant ingrowth of these progeny. Also, the opportunity for dry yellowcake containing these radionuclides to become airborne and leave the plant is minimal. Finally, speciation of radionuclides collected during air sampling inside the Lost Creek plant confirms the assumption that the concentrations of airborne thorium-230, radium-226, polonium-210 and lead-210 are very low. In all 8 samples analyzed to date, the concentrations of thorium-230, radium-226, lead-210 and polonium 210 are either less than 4% of the respective DAC in 10 CFR 20 App B (using the most stringent solubility class W for thorium-230) or below detection even when uranium is present.

Wellfield

There are two potential sources of releases of principal radionuclides to the unrestricted area in the wellfield: lixiviant spills and wellheads.

A chemical analysis of production fluid collected in December 2014 revealed the following concentrations of dissolved radionuclides in pCi/L in addition to natural uranium and radon:

Pb-210	13
Po-210	4.1
Ra-226	2,700
Ra-228	39.5
Th-230	0.7
Th-234	2,290

Based on these concentrations, the principal radionuclides in wellfield spills will be uranium, radon, radon daughters, radium-226 and thorium-234. The concentration of thorium-234 in the December sample of production fluid may be an outlier. If additional analysis indicates the concentration is insignificant then thorium-234 will be removed from the list of principal radionuclides.

When a spill occurs, the quantity of the principal radionuclides released will be based on the most recent measurement of those parameters in the solution. Attempts to measure the airborne concentration of radon and radon daughters at the spill site will not be made since several significant sources of error, such as wind, ice, adsorption and background levels, will render measurements unreliable. Even if airborne concentrations could be determined, it would be impossible to accurately determine the volume of air emanating from the spill.

With regard to wellheads, the principal radionuclides radon and radon daughters could be released from unsealed injection and production wellheads or during degassing at injection wells. However, radon tends to stay within the water column instead of migrating into the air (see EPA 520/1-86-009, Final Rule for Radon-222 Emissions from Licensed Uranium Mill Tailings, August 1986, Background Information Document, Section 3.4.3) unless the water is disturbed such as when a well is degassed. Uranium, radium, and other radionuclides will remain in the water column and won't be released with the gas and are therefore not considered principal radionuclides emitted from wellheads. Radon and radon daughters released beyond production and injection well covers may be undetectable due to relatively low concentrations getting statistically lost within relatively high background levels in the Great Divide Basin. However, in order to demonstrate compliance with 10 CFR 40.65, LCI will measure the concentrations of radon and radon daughters being released outside well covers by installing radon track etch devices and taking modified Kusntez measurements as described in Table 1. If after one year of measurements the amount of radon or radon daughters emanating from wellheads cannot be discerned from background, the frequency of monitoring for the radionuclide(s) at baseline concentrations will be reduced as follows: radon track etch cups will be reduced to semi-annual, and the frequency of modified Kuznets will be reduced to semi-annual. If the samples collected at a reduced frequency indicate the concentration of radionuclides may be above background, the schedule presented in Table 1 for header houses will resume at the beginning of the next quarter. A t-test, or other acceptable statistical test, of the data from the sampling locations in the wellfield will be compared to sampling locations upwind far from the plant and wellfield in order to determine if the wellfield readings can be discerned from background.

Header Houses

The principal radionuclides present in header houses are uranium, radon, and radon daughters. However, air measurements taken within header houses to date show that the concentration of uranium is at background and the level of radon is also commonly at background. In order to demonstrate compliance with 10 CFR 40.65, LCI will measure the concentrations of uranium, radon and radon daughters as outlined in Table 1. If after one year of monitoring the concentration of any specific principal radionuclide emanating from header houses cannot be discerned from background, as determined by an appropriate statistical analysis, the percentage of header houses monitored will be reduced from 20% to 10%. If the reduced percentage samples indicate the concentration of radionuclides may be above background, the schedule presented in Table 1 for header houses will resume at the beginning of the next quarter.

Each of the radon track etch devices listed in Table 1 will be changed out approximately quarterly and sent for analysis.

The air flow rates of header house ventilation fans will be determined by direct measurement in most cases. However, if a direct measurement cannot be made, the design flow rate will be used. The flow rates will be determined at least annually and any time there is a design or process change that may impact the flow rate for as long as measurements of principal radionuclides are required.

The radon track etch devices will be Landauer's Radtrak® devices or a similar device approved by the RSO. Radtraks® provide passive time integration of alpha particle tracks only and are shipped in a film-foil bag which meets Military specification MIL-B-131, Class 1. Manufacturer specifications are provided in Attachment 1 along with specifications of other radon monitoring devices.

Uranium particulate sampling will follow the method previously described in Section 5.7.3.1 of the Technical Report with the addition of the sample points and frequencies listed in Table 1 of this submittal.

Radon daughter concentrations will be measured using the modified Kusnetz method described in Section 5.7.3.3 of the Technical report with the addition of the sample points and frequencies listed in Table 1 of this submittal.

Please note that the above response to concerns regarding license condition 12.10A avoids citing 10 CFR 20 Appendix B Table 2 effluent concentrations since License Condition 12.10A requires a demonstration of compliance with 10 CFR 40.65 (i.e. characterization of the total "quantity" instead of "effluent concentrations" limits of principal radionuclides).

Finally, the NRC cited 10 CFR 20.1302 several times in the portion of their November 3, 2014 letter listing concerns about license condition 12.10A. The above response to NRC's concerns regarding license condition 12.10A does not discuss measurement of radionuclides at environmental stations; such as at the downwind fence. Once again, this is because license condition 12.10A deals with compliance with 10 CFR 40.65 which requires the characterization of the "quantity" of radionuclides released from the restricted area and not the concentration of effluent that a member of the public may be exposed to. NRC's concerns regarding compliance with 10 CFR 20.1302 are discussed in detail in our response to concerns related to license condition 12.10B; immediately below.

12.10B Evaluate the members(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302

Response:

In order to evaluate the member(s) of the public likely to receive the highest exposure from licensed operations, two types of members of the public must be considered: visitors to the controlled and/or restricted facility (such as contractors and delivery drivers) and members of the public who don't enter the restricted or controlled area but may still receive a dose from effluent (such as ranchers). The dose to each of these categories will be determined annually as discussed below. LCI intends to comply with option (b)(1) of 10 CFR §20.1302 which states: *"(b) A licensee shall show compliance with the annual dose limit in §20.1301 by – (1) Demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operation does not exceed the annual dose limit."* The annual dose limit to a member of the public is 100 mrem.

Visitors to Controlled/Restricted Facility

The record of visitors to the Lost Creek Facility indicates delivery drivers spend the most time at the site. For delivery drivers who are likely the highest exposed member of the public outside the restricted area since they spend considerably more time near the plant site than any other member of the public, the dose will be determined by taking the annual dose received in the warehouse, where the driver drops off and picks up deliveries, and correcting it for the hours a delivery driver may be present. The time of exposure will be conservatively estimated at 173 hours per year. During 2014 the maximally exposed delivery driver was likely the UPS driver who delivered to the site nearly every weekday and stayed at the site for about 40 minutes per delivery (total of 173 hours per year). UPS changed out drivers several time during the year so the above estimate is conservative. The TEDE in the warehouse will be determined by combining the dose determined from the following measurements and adjusted for the time the delivery driver is present (see attached Table 2 and Figure 2 for additional details):

1. External gamma exposure rate will be measured in the warehouse quarterly.
2. Dose from radon will be determined by placing a radon track etch device in the warehouse and be changed out quarterly.
3. Dose from radon daughters will be determined by performing quarterly modified Kusnetz sampling in the warehouse.
4. Dose from uranium particulate will be determined by taking and analyzing air filter samples quarterly.

If, after a year, the data shows the potential exposure from any of these measurements cannot be discerned from background, as evidenced by a t-test or other appropriate statistical analysis comparing warehouse data to data collected at the HV-3 upwind station in Section 25, the rate of sampling will be reduced to once per year for each parameter at baseline levels to ensure there is no change. If annual measurements indicate the concentration of radionuclides may be discernable from background, the schedule outlined in Table 2 will resume at the beginning of the next quarter.

For visitors to the plant, such as contractors, the dose will be determined by taking the annual dose of the maximally exposed plant operator (exclusive of the dryer operator) and correcting it for the hours the visitor to the plant may be present. The time of exposure will be conservatively estimated to be 24 hours per year (3 work days). This estimate is very conservative since visitors to the plant, such as contract labor, are required to take the complete radiation safety training if they will be working in the plant without direct supervision by an experienced radiation worker. Once the training, followed by a written test, is successfully completed, the visitor to the plant is no longer considered a member of the public but is instead recognized as a radiation worker not subject to the requirements of 10 CFR 20.1302.

The occupational dose measurements described in the Technical Report will be made to determine the dose to the plant operator. The dose to the maximally exposed plant operator will be adjusted for the time the visitor was in the plant (expected to be no more than 24 hours in any given year).

The highest exposure to visitors is expected to be extremely low due to limited time spent at the plant. The evaluation of visitors will follow the method described in 10 CFR 20.1302(b)(1). Each year the RSO will use the measured dose to employees from the previous year to determine the potential maximum dose to visitors. The anticipated highest exposure to two types of visitors will be determined annually: delivery drivers and visitors to the plant. In both cases the exposure will be based on actual measurements of dose in the warehouse and the plant. The dose will be adjusted to reflect the estimated time the visitors may be exposed to radiation resulting from licensed activities.

Finally, during routine gamma surveys (as described in Section 5.7 of the Technical Report) the RSO, or HPT, will ensure the dose does not exceed 2 mrem outside the restricted area in any one hour pursuant to 10 CFR 20.1301(a)(2). The gamma instrument will be a Ludlum Model 19 or equivalent as determined by the RSO.

Members of the Public Beyond the Controlled/Restricted Facility

LCI recognizes that compliance with 10 CFR 20.1302 requires a demonstration that the annual TEDE to the member of the public likely to receive the highest dose from the licensed operation does not exceed the annual dose limit of 100 mrem. The regulation does not require a demonstration of where the highest radiation levels occur. As pointed out in the NRC's November 3, 2014 letter, numerous technical challenges, such as wind direction, affect where the maximum radiation level is at any given point in time. Therefore, in order to develop a program which will ensure dose to the public remains below 100 mrem/year and to evaluate the member of the public likely to receive the highest dose from licensed activities, LCI has determined: where members of the public may be, how long the member of the public will be present, and methods to measuring what the doses to members of the public could be at these locations.

The highest radiation levels beyond the controlled/restricted facility will likely be in the downwind direction from the plant since the concentration of uranium, radon, and radon daughters will, on average, likely be highest in the downwind direction. MILDOS modeling performed during licensing indicated the highest radon progeny concentration in soils would be in the area of the ponds immediately east of the plant. Figure 3 shows the wind rose diagram for all data collected from the calibrated on-site meteorological station from June 14, 2007 through June 14, 2014. The plot shows that the wind direction is highly variable but most commonly blows from the west southwest to the east northeast. This means that the prevalent wind direction from the plant is generally into the fenced holding pond area. Since access to members of the public into the holding ponds and surrounding area is carefully controlled (likely less than 4 hours per year) the potential TEDE is very low and not likely the location of the maximally exposed member of the public.

The presence of other members of the public such as ranchers, campers, and hunters in the vicinity of the plant has been virtually nonexistent since 2006 when LCI began routine work at the site. There are no stock watering wells, campgrounds or other infrastructure routinely maintained by the public in the vicinity of licensed activity. Therefore, these members of the public are unlikely to be the highest and no attempt to routinely measure them will occur.

Downwind Monitoring and Sampling

In order to measure and better understand the distribution of radionuclide effluent in the vicinity of the plant and to collect data that may be used to determine exposure to members of the public, a total of seven (7) radiologic sampling stations will be established as shown in Figure 2 (one of the 7 stations will be existing sample station HV-2 which includes a hi-vol sampler, radon track etch device and low level gamma device). These locations were selected because the wind direction data collected over the past seven years indicates these locations are in the predominant downwind direction, see Figure 3. Sample station E13C was selected because the predominant wind direct from the plant intersects the nearest two-track road where a member of the public could be present; although as previously stated the occupancy time is expected to be virtually zero. Radionuclide concentrations and radiation rates at each sampling station will be determined as follows: radon will be measured using a radon track etch device changed out quarterly, gamma measurements will be made quarterly using a Ludlum Model 19 meter or similar device, air particulate filter samples for uranium will be collected quarterly, and modified Kusnetz sampling for radon daughters will occur quarterly (see Table 2). Data collected from these stations will not be used to calculate exposures to the public unless the RSO determines a member of the public may occupy the area for more than a few hours and the exposure levels are high enough that the individual may be the highest exposed member of the public.

The frequency of downwind monitoring and sampling may be reduced to semi-annual after at least one year of measurements for any parameter which cannot be distinguished from background levels as determined by a valid statistical analysis.

Although not in the predominant downwind direction, additional monitor stations will be established at the soda ash silo and the propane tank in order to ensure exposure in these areas to members of the public are not likely the maximum (see Table 2 and Figure 2). The monitoring will be the same as that described for the downwind sampling points. The combination of the nine sites (7 downwind and 2 additional sites in chemical delivery areas) will ensure that dose levels in these areas can be determined in the event the maximum exposure occurs in these locations. A review of visitor records shows that members of the public spend minimal time near the soda ash silo and near the propane tank.

The RSO shall review the above program annually to ensure it adequately identifies the maximally exposed member of the public and also properly determines their exposure using the methods set forth in 10 CFR 20.1302.

12.10C Discuss and identify how radon (radon-222) progeny will be factored into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2.

Response:

As mentioned in response to License Condition 12.10B, at locations where the maximum exposure to a member of the public is likely to occur, radon track etch detectors will be deployed and the modified Kusnetz method will be used to determine the progeny equilibrium fraction. The radon progeny equilibrium fraction will be used to adjust the dose estimate to dose with radon daughters present as described in Section 2.3 of NRC Reg Guide 8.30 *"Health Physics Surveys in Uranium Recovery Facilities."*

12.10D Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire license area from licensed operations will be accounted for in, and verified by, surveys and/or monitoring.

Response:

The three main routes of dose from radiation at a uranium mine are external exposure, ingestion, and inhalation. Employee's doses are estimated and accounted for with several different types of surveys and monitoring.

External dose is measured by personal OSL radiation badges worn by employees who work routinely in the plant and selected employees who would be representative of various job types. External exposure is routinely measured with a NaI gamma detector to determine where external exposure is elevated above background and assists in finding ways of reducing exposure to achieve ALARA. Since OSL badges are worn continually, they effectively measure the external gamma dose and will be the sole source of data when determining the external dose from gamma.

Inhalation doses are calculated from the results of air samples for radon daughters and long lived radionuclides (uranium in particular). Area air samples are collected in areas potentially/likely containing these airborne radionuclides. There are several sampling areas including in the plant, the office areas, header houses, and disposal well pump houses as described in Section 5.7 of the Technical Report. Whenever airborne concentrations may be elevated for a specific activity (dryer operations or RWPs) breathing zone air samples are collected.

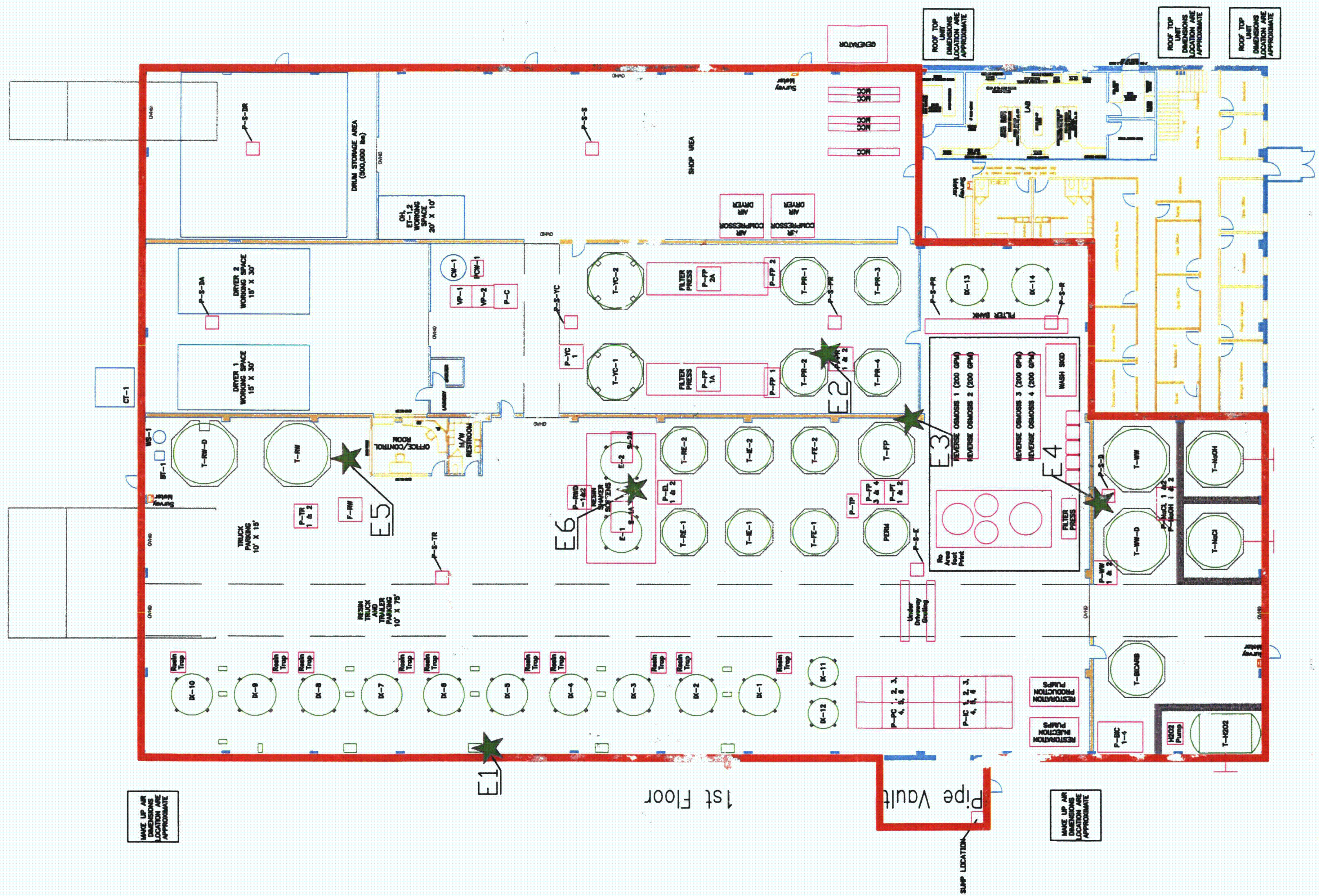
As a check on the procedures for protection from inhalation and ingestion, bioassays are collected. A positive bioassay for uranium indicates the procedures are not being followed, or the procedures are not adequately protecting against radioactive material intake.

Outdoor surveys for occupational dose considerations are not necessary because dose and environmental measurements have shown that the dose contributions outside the plant and header houses are insignificant. At the discretion of the RSO, additional surveys may be performed if the environmental levels, including the results of samples and monitoring described in response to License Condition 12.10B, warrant inclusion in the occupational dose.

Sincerely,

John W. Cash
Vice President

Cc: NRC Deputy Director, Decommissioning and Uranium Recovery Licensing Directorate
Theresa Horne, Ur-Energy, Littleton
Mr. John Saxton, NRC (via email)



SCALE IN FEET

0 300 600

LEGEND

Restricted Area

Wall/Door

Approximate Sampling Point

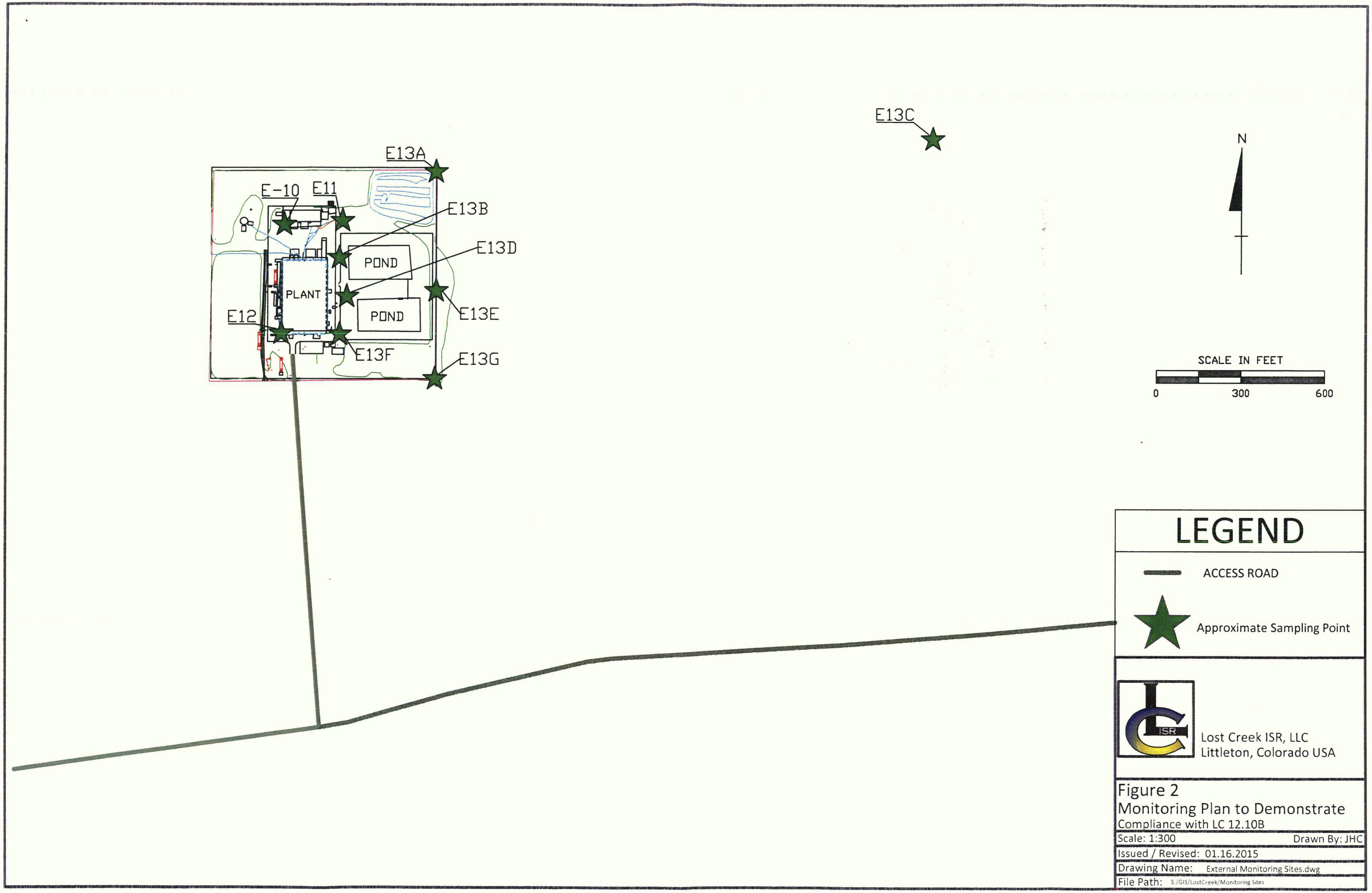
Lost Creek ISR, LLC
Littleton, Colorado USA

Figure 1
Lost Creek Plant Monitoring
for Compliance with 10CFR 40.65

Scale: 1:300 Drawn By: JHC

Issued / Revised: 01.14.2015

Dwg No.



Lost Creek ISR, LLC
Littleton, Colorado USA

Figure 2
Monitoring Plan to Demonstrate Compliance with LC 12.10B

Scale: 1:300 | Drawn By: JHC
Issued / Revised: 01.16.2015
Drawing Name: External Monitoring Sites.dwg
File Path: S:/GIS/LostCreek/Monitoring Sites

Figure 3: Wind Rose Diagram from Lost Creek Meteorological Station (Date range: 6/14/2007 14:00 to 6/14/2014 14:00)

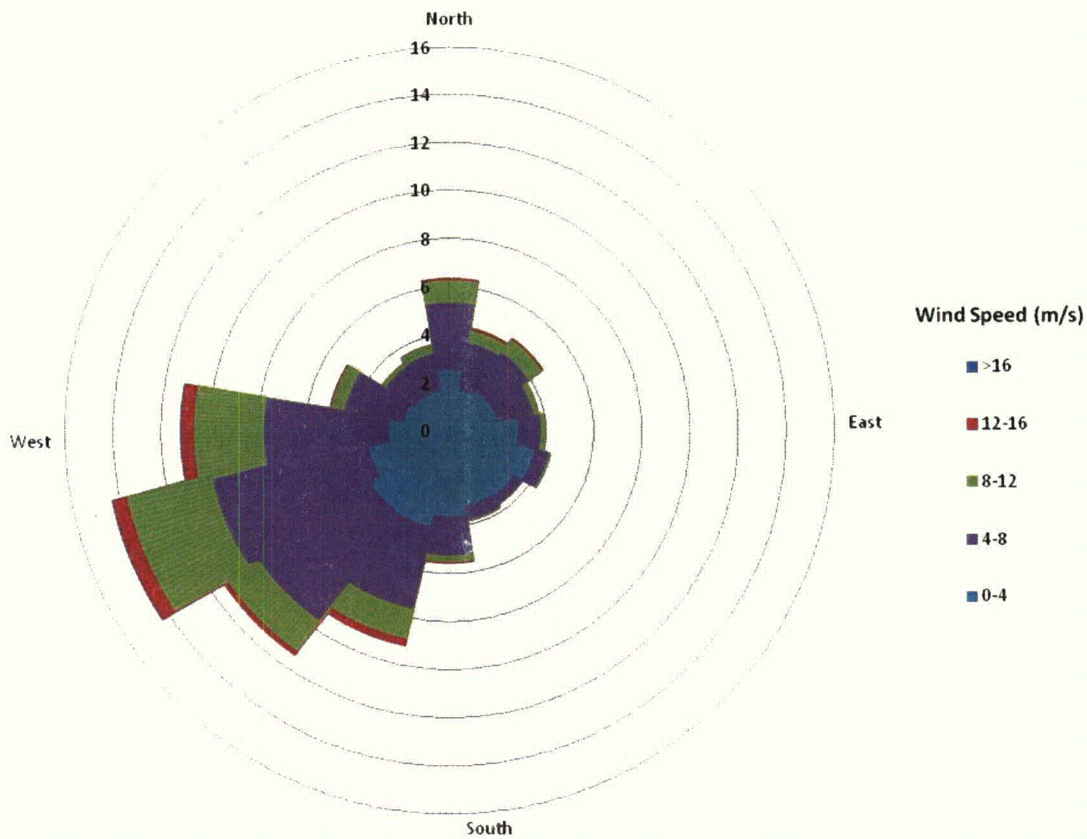


Table 1: Monitoring Plan to Demonstrate Compliance with LC 12.10A

Air Effluent

Sample Point	Site #	Radon		Radon Daughters		Uranium		Comment
		Method	Frequency	Method	Frequency	Method	Frequency	
Plant Wall Vent	E1	Radon Track Etch	Quarterly	No sampling. Radon assumed to be in equilibrium with its daughters	3/Quarter	Air Filter	Semi-annually	
Precipitation Vent	E2	Pylon or Rad7 instrument or equivalent	3/Quarter	No sampling. Radon assumed to be in equilibrium with its daughters	3/Quarter	No Sampling/See Comment		This is a wet process with no opportunity for dry airborne uranium particulate. Therefore, no sampling for uranium will ocurr.
Elution Vent	E3	Pylon or Rad7 instrument or equivalent	3/Quarter	No sampling. Radon assumed to be in equilibrium with its daughters	3/Quarter	No Sampling/See Comment		This is a wet process with no opportunity for dry airborne uranium particulate. Therefore, no sampling for uranium will ocurr.
Waste Water Vent	E4	Pylon or Rad7 instrument or equivalent	3/Quarter	No sampling. Radon assumed to be in equilibrium with its daughters	3/Quarter	No Sampling/See Comment		This is a wet process with no opportunity for dry airborne uranium particulate. Therefore, no sampling for uranium will ocurr.
Resin Transfer Vent	E5	Pylon or Rad7 instrument or equivalent	3/Quarter	No sampling. Radon assumed to be in equilibrium with its daughters	3/Quarter	No Sampling/See Comment		This is a wet process with no opportunity for dry airborne uranium particulate. Therefore, no sampling for uranium will ocurr.
IX Column Vents	N/A	No Sampling/See Comment		No Sampling/See Comment		No Sampling/See Comment		The IX column vents are only used in rare emergencies. Otherwise, the production fluid is isolated from the enviroment by a valve. Therefore, sampling will not ocurr.
Shaker Deck Vent	E6	Pylon or Rad7 instrument or equivalent	1/Quarter	No sampling. Radon assumed to be in equilibrium with its daughters	3/Quarter	No Sampling/See Comment		This is a wet process with no opportunity for dry airborne uranium particulate. Therefore, no sampling for uranium will ocurr.
Dryer Vent	N/A	No Sampling/See Comment		No sampling/See Comment		No Sampling/See Comment		Dryer discharge runs through a HEPA filter before entering the main plant area. Once discharged gas is in the plant it will enter the outdoor environment through the plant's general ventillation. The samples collected at the general ventillation will measure the discharge from the dryer that is being released to the environment.
Header House Fan	E7	Radon Track Etch	20% of houses once/qtr	Air Filter w/ Modified Kusnetz	20% of houses once/qtr	Air Filter	20% of houses semi-annually	Samples collected at discharge of operating header houses. Results from measured header houses will be applied to all header houses to determine total effluent
Injection Wellhead	E8	Radon Track Etch	1/Quarter	Air Filter w/ Modified Kusnetz	3/Quarter	No Sampling/See Comment		Modified Kusnetz samples collected at the wellhead cover on 3 operating wells/Qtr. Uranium in the wellhead is contained in solution and therefore there is no opportunity for release of uranium particulate. Therefore, no uranium analysis will ocurr. Average results will be applied to all injection wells.
Production Wellhead	E9	Radon Track Etch	1/Quarter	Air Filter w/ Modified Kusnetz	3/Quarter	No Sampling/See Comment		Modified Kusnetz samples collected at the wellhead cover on 3 operating wells/Qtr. Uranium in the wellhead is contained in solution and therefore there is no opportunity for release of uranium particulate. Therefore, no uranium analysis will ocurr. Average results will be applied to all injection wells.

Liquid Effluent

Spilled Mining Solution	N/A	The uranium and radium-226 concentration of fluids released to the environment will determined based on recent measurements of similar fluid. For example, if a spill from a production well occurs, the uranium concentration will be assumed to be equivalent to the most recent assay.

The frequencies presented are minimums. Additional sampling/monitoring may occur as deemed necessary by the RSO

Table 2: Monitoring Plan to Demonstrate Compliance with LC 12.10B

Sample Point	Site #	Radon		Radon Daughters		Airborne Uranium		External Exposure		Comment
		Method	Frequency	Method	Frequency	Method	Frequency	Method	Frequency	
Warehouse	E10	Track Etch Device	Quarterly	Modified Kusnetz	Quarterly	Air Filter	Quarterly	Direct gamma	Quarterly	
Propane Tank	E11	Track Etch Device	Quarterly	Modified Kusnetz	Quarterly	Air Filter	Quarterly	Direct gamma	Quarterly	
Soda Ash Silo	E12	Track Etch Device	Quarterly	Modified Kusnetz	Quarterly	Air Filter	Quarterly	Direct gamma	Quarterly	
Plant	Various	See Comment		Modified Kusnetz	See Section 5.7.3.3 of TR	Air Filter	See Section 5.7.3.1 of TR	OSL Badges	Quarterly	Radon measurements will not be taken since it will be assumed radon is in equilibrium with its daughters
Downwind	E13a thru E13g	Track Etch Device	Quarterly	Modified Kusnetz	Quarterly	Air Filter	Quarterly	OSL Badge	Quarterly	The results of this monitoring will not be used to determine the dose to the member of the public likely to receive the highest dose unless the RSO determines that the maximum exposure to a member of the public likely ocurred in this area.

The frequencies presented are minimums. Additional sampling/monitoring may occur if deemed necessary by the RSO

Attachment 1

Specifications of Detectors

(Landauer Radtrack®, Duridge RAD7, and Pylon AB6A with 600A cell)

RADTRAK®
ALPHA TRACK RADON DETECTOR SPECIFICATIONS

1. Detectors provided are passive and provide for the time integration of alpha particle tracks only.
2. Pricing includes the radon detector, all processing and analysis of exposed detectors, instructions, reporting of results, seals, and long-term storage of the processed detector for a period of at least 25 years.
3. Detector holders are enclosed in a cavity composed of electrically conducting material with filtered openings to permit diffusion of radon gas <u>only</u>.
4. In order to prevent exposure prior to use, detector holders are packaged in film-foil bags which meet Military specification MIL-B-131, Class 1. Paper-foil laminates are not acceptable.
5. Each detector is identified with a computer controlled laser engraved number prior to shipment to assure permanence of identity through the etching process and inhibit replication of numbers. A matching identification number is included on the detector holder and containment pouch. Reported data will reference this number.
6. Radon exposed calibration detectors and blanks are included in each etched batch of client detectors to verify proper etching conditions and account for variations in etching parameters.
7. Analysis of etched detectors is performed using computer controlled image analysis instrumentation.
8. A calibrated radon exposure chamber is on site.
9. The minimum level of detection is 30 pCi/l days i.e., 0.33 pCi/l based on 90 days.
10. A metallic label is provided to seal the sampling holder, following the exposure period, to minimize subsequent exposure to radon during transit.

11a. CR-39 type material shall be used. Both sides of the detector surface shall exhibit statistically equal sensitivity to alpha particles whose energy is equal to those emitted by radon-222 and its progeny. The background artifacts on both detector surfaces shall be statistically equal and equal to or less than 0.30 tracks per mm^2 at the time the chip is installed in the detector holder.

11b. Each CR-39 type chip shall be "keyed" to assure that the exposed side is always known during insertion into the detector housing and during the track counting process.

12. The detector shall be enclosed in a cylindrical housing which has filtered openings aligned perpendicular to the detector chip's surface permitting the entry of radon gas into the container, but exclude radon progeny and particulate matter protected by the Landauer patent. Upon request, a thoron proof filter can be used to provide "Rn-222 only" measurements.
13. The sensitive detector surface must be positioned at a 90° angle from the filtered surface to avoid errors in precision caused by radioactive decays which occur at different depths in the filter or external to the housing.
14. The detector surface must face the curved interior surface of the housing to add correction for angular effects of radon progeny alpha emission following plate-out on the interior surface of the housing.

15a. The approximate range of the lowest energy alpha particle (6 MeV) from radon progeny is approximately 40 microns in CR-39 type plastic and 43 millimeters in air at STP (0°C and 760 Torr).

15b. It is necessary that the detector be capable of measurements in environments which range in temperature between 0°F and 100°F (-17.8°C and 43.3°C).

15c. The maximum range of a 6.0 MeV alpha particle in air at the -17.8°C (0°F) is about 41 millimeters.

15d. Proper etching of CR-39 type material for alpha particle tracks is estimated to remove 10 microns of detector surface which reduces the effective range in air of a 6.0 MeV alpha particle to approximately 31 mm at -17.8°C (0°F).

15e. As a result, no inside surface of the housing shall have a distance greater than 31 mm from the detector surface. This distance assures accuracy even at high altitudes.

16. A metallic seal shall cover the joining surface of the top half and bottom half of the cylindrical housing.

LANDAUER®

Landauer, Inc., 2 Science Road, Glenwood, Illinois 60425-1586 Telephone: (800) 528-8327 Facsimile: (708) 755-7048

DURRIDGE
RADON INSTRUMENTATION

DURRIDGE COMPANY INC.
524 Boston Road, Billerica, MA 01821
Tel: (978) 667-9556, Fax: (978) 667-9557
www.durridge.com

RAD7 Specifications

Specifications for the RAD7 exceed those of all radon gas monitors made in North America, as well as those in its price range world-wide. This is a partial list of specifications that make the RAD7 so highly regarded in the field.

Part 1 Functionality

Modes of Operation	SNIFF Rapid response and rapid recovery radon measurement THORON Radon and thoron measured simultaneously and independently NORMAL High sensitivity AUTO Automatic switch from SNIFF to NORMAL after three hours run GRAB Analysis of grab samples WAT Automatic analysis of water samples with RAD H_2O accessory
Measurements	Radon in air with Sniff protocol for quick, spot reading Thoron protocol for searching for radon entry points Radon in air 1-day, 2-day or weeks protocol for long term measurement Radon in water batch samples with RAD H_2O and Big Bottle RAD H_2O Continuous radon in water with RAD AQUA and Radon-in-Water Probe Radon in soil gas with Soil Gas Probe and Active DRYSTIK Radon emission from soil and hard surfaces with surface emission chamber Bulk radon emission from bulk materials and objects
Data Storage	1,000 records, each with 23 fields of data Log of printer output also stored
Sample Pumping	Built-in pump draws sample from chosen sampling point Flow rate typically 800mL/min
Print Output	Short, medium or long format data printed after each cycle Run summary printed at end of run, including averages and spectrum
PC Connectivity	RS232 serial port, full remote control implemented in CAPTURE Software
Audio Output	GEIGER Tone beeps for radon and thoron counts CHIME Chime only at the end of each cycle, otherwise silent OFF No sound
Tamper Resistance	TEST LOCK command locks keypad to secure against tampering

Part 2 Technical Specifications

Principle of Operation	Electrostatic collection of alpha-emitters with spectral analysis Passivated Ion-implanted Planar Silicon detector SNIFF mode counts polonium-218 decays NORMAL mode counts both polonium 218 and polonium 214 decays
Built-In Air Pump	Nominal 1 liter/minute flow rate Inlet and outlet Luer connectors

Connectivity	RS-232 port up to 19,200 baud rate USB adaptor is included with every RAD7
Measurement Accuracy	+/-5% absolute accuracy, 0% - 100% RH
Nominal Sensitivity	SNIFF mode, 0.25 cpm/(pCi/L), 0.0067 cpm/(Bq/m^3) NORMAL mode, 0.5 cpm/(pCi/L), 0.013 cpm/(Bq/m^3)
Radon Concentration Range	0.1 - 20,000 pCi/L (4.0 - 750,000 Bq/m^3)
Intrinsic Background	0.005 pCi/L (0.2 Bq/m^3) or less, for the life of the instrument
Recovery Time	Residual activity in Sniff mode drops by factor of 1,000 in 30 minutes
Operating Ranges	Temperature: 32° - 113°F (0° - 45° C) Humidity: 0% - 100%, non-condensing
Cycle Range	User controllable number of cycles, from 1 to 99 to unlimited, per run User controllable cycle time, from 2 minutes to 24 hours
CAPTURE Software	Compatible with Microsoft Windows XP and 7, and Mac OS X Automatic RAD7 location, connection and data download Graphs radon, thoron, temperature and humidity over time Automatic humidity correction Statistical analysis tools track concentration averages and uncertainties Chart Recorder mode provides real-time RAD7 status monitoring Control RAD7 operations from computer via direct or remote connection Automatic calculation and display of radon in water for RAD AQUA Automatic combination of multiple RAD7 data

Part 3 Physical Specifications

Dimensions	11.5" x 8.5" x 11" (29.5 cm x 21.5 cm x 27.9 cm)
Weight	9.6 pounds (4.35 kg)
LCD Display Output	2 line x 16 character, alpha-numeric display
Case Material	High density polyethylene
Infrared Printer	Chamjin NewHandy 700 Wireless Infrared Printer included
Power Supply	11-15V DC (12V nominal) @ 1.25A, center pin positive, or internal rechargeable batteries (5Ah)
Battery Longevity	24 hours in SNIFF mode; 72 hours in Monitor mode

Revision 2014-10-13

DURRIDGE RADON INSTRUMENTATION

Leaders in professional radon instrumentation and analysis solutions

Search

DURRIDGE RAD7

Electronic radon detector with real-time monitoring and spectral analysis

The DURRIDGE RAD7 is a truly versatile radon detector of mature and yet still state-of-the-art design. Its specifications match or exceed those of the most expensive radon measurement devices in the world. At the same time, it incorporates a number of exclusive features that are found in no other radon detector, regardless of price. Incredibly, the RAD7 is affordable.

The RAD7 is a sophisticated measuring instrument widely used in laboratories and research work around the globe, by radon testers, mitigators and home inspectors, in mines and deserts, on the ocean and up volcanoes, at extremes of temperature.

The RAD7 is also the simplest computer-driven electronic detector to use, with pre-programmed set-ups for common tasks. It's built to withstand everyday use in the field. A rugged, handsome case encloses the detector, which is self-contained and self-sufficient. The RAD7 comes complete, with a built-in air pump, rechargeable batteries, and a wireless infrared printer. The printer can be left in your office or your car, when desired, and the detector will collect data and store it for later printing or downloading to a PC.

The RAD7 is a Sniffer that uses the 3-minute alpha decay of a radon daughter, without interference from other radiations, and the instantaneous alpha decay of a thoron daughter. The RAD7 sniffs out entry points and radon gushers and recovers in minutes from high radon exposures. The RAD7 is also a Continuous Monitor that measures the EPA action level of 4 pCi/L, with 10% standard deviation, in under two hours. At the end of each run, the detector prints out a complete report.

RAD7 electronic radon detector

RAD7 Advantages

Precision and Performance

- Fastest response and recovery times of any electronic monitor/sniffer on the market.
- Measures EPA action level of 4 pCi/L in just one hour.
- Recovers from radon highs in minutes - not hours.
- Spectrum printout verifies correct operation of instrument in field.

Convenience and Ease of Use

- All-in-one complete, compact, portable unit in handsome rugged carrying case.
- Microcomputer directs you, step by step, so you can do what you want to do.
- Programmed set-ups for often-used tests.
- Audible radon and thoron counts lets you hear the hot spots.

RAD7 with optional bluetooth adaptor

Security and Flexibility

- Tamper-proof key-lock command secures your RAD7 and assures uninterrupted testing.
- Easily portable: The RAD7 weighs just 11 pounds (5 kg).
- Displays, prints, and downloads radon data in your choice of units.
- Immunity to build-up of 210pb.

Expandability and Value

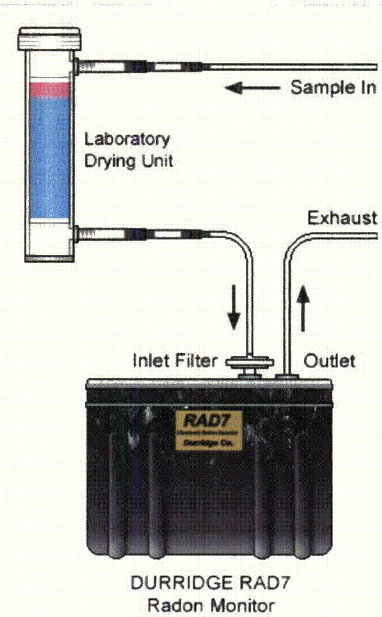
- Includes wireless printer and infra-red data link for on-the-spot printouts.
- Available with a wide range of accessories for measuring radon in water and below ground.
- Versatile connectivity with an RS-232 port and USB compatibility adaptor
- Includes CAPTURE software for data retrieval and analysis. Full Macintosh and Windows compatibility.
- Includes rechargeable batteries and extensive documentation.

Operating the RAD7

The RAD7 is remarkably easy to use. It's ready to operate from the moment you turn it on. The first thing you will see is the Setup Review, which displays the current settings. This allows you to check that your machine is set up the way you want it for your intended use.

Now you and your RAD7 are ready to go to work. The machine is preset for a 1- or 2-day test... or you can preset for your particular job that day. When you arrive on site, just push the buttons and the test runs automatically.

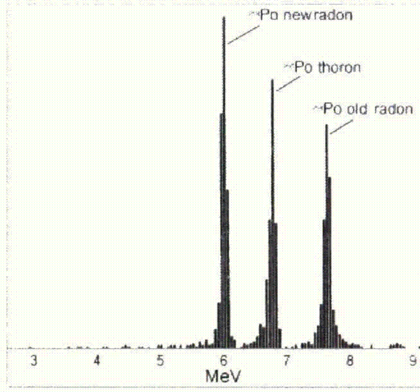
A RAD7 exclusive feature is "Auto" mode. This starts a test in Sniff mode for quick response, a base-line reading. After 3 hours it automatically switches to "Normal" mode for the remainder of the test, assuring statistical precision.



RAD7 Standard Setup Diagram

You can leave your RAD7 for a 24-hour, 48-hour or any-hour test, knowing that the measurements will be correct, thanks to the "Test Lock" command, which locks the machine until you return. The display shows "DURRIDGE RAD7", the test continues, and no amount of tampering - intentional or unintentional - can influence it.

action level of 4 pCi/L, with 10% standard deviation, in one hour. At the end of each run, the detector prints out a complete report.



Alpha Energy Spectrum

USB and Bluetooth Connectivity

Stored RAD7 data may be downloaded to a computer using a USB or serial connection. DURRIDGE offers a dedicated RAD7 communications software package called CAPTURE, which automatically transfers RAD7 data to disk, displays radon graphs, and produces a variety of supplementary information. CAPTURE can also monitor a RAD7 in real time with its Chart Recorder. Learn more about CAPTURE here.

For situations where the RAD7 can not be directly connected to a computer, DURRIDGE offers the Parani SD1000 Serial to Bluetooth Adaptor. This adaptor offers a 100 meter wireless range, and it comes pre-configured for plug and play compatibility with the RAD7 and CAPTURE. An optional 16 hour battery allows the adaptor to be used even in the absence of a reliable power source.

RAD7 Specifications

Functionality:

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Audio Output	GEIGER Tone beeps for radon and thoron counts CHIME Chime only at the end of each cycle, otherwise silent OFF No sound
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Nominal Sensitivity	SNIFF mode, 0.25 cpm/(pCi/L), 0.0067 cpm/(Bq/m3) NORMAL mode, 0.5 cpm/(pCi/L), 0.013 cpm/(Bq/m3)
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Intrinsic Background	0.005 pCi/L (0.2 Bq/m3) or less, for the life of the instrument
Recovery Time	Residual activity in Sniff mode drops by factor of 1,000 in 30 minutes
Operating Ranges	Temperature: 32° - 113°F (0° - 45° C) Humidity: 0% - 100%, non-condensing
Cycle Range	User controllable number of cycles, from 1 to 99 to unlimited, per run User controllable cycle time, from 2 minutes to 24 hours
CAPTURE Software	Compatible with Microsoft Windows XP and 7, and Mac OS X Automatic RAD7 location, connection and data download

- Graphs radon, thoron, temperature and humidity over time
- Automatic humidity correction
- Statistical analysis tools track concentration averages and uncertainties
- Chart Recorder mode provides real-time RAD7 status monitoring
- Control RAD7 operations from computer via direct or remote connection
- Automatic calculation and display of radon in water for RAD AQUA
- Automatic combination of multiple RAD7 data

Physical Specifications:

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Power Supply	11-15V DC (12V nominal) @ 1.25A, center pin positive, or internal rechargeable batteries (5Ah)
Battery Longevity	24 hours in SNIFF mode; 72 hours in Monitor mode

Documentation

RAD7 Manual (PDF)

RAD7 Specifications (PDF)

Media


RAD7 and Standard Accessories (Illustration)

Getting Started: 1-Day Test with the RAD7 2014 YouTube video (9 min.)

Featured Articles

The RAD7: How Technology Translates to Performance (HTML)

Application Note: Sniffing for Thoron (HTML)

Related Accessories

RAD H_2O (HTML)

RAD AQUA (HTML)

Water Probe (HTML)

Soil Gas Probes (HTML)

DRYSTIK (HTML)

Duty Cycle Controller (HTML)

Range Extender (HTML)

Big Bottle RAD H_2O (HTML)

Emission Chambers (HTML)

Relay Box (HTML)

RAD7 Software

CAPTURE Software for Macintosh OSX and Windows (HTML)

Purchasing

Price List (HTML)

Phone: (978) 667-9556 | Support: support@durridge.com

PYLON AB6A

Active Cell Detectors

The reliable, versatile, and user-friendly solution for a wide variety of radiation monitoring applications.

We understand that reliable radon detection is not a luxury - it is an absolute necessity.

The Active Cell Detectors are Lucas type cells that are used on our next generation laboratory-grade instrument, the Pylon AB6A Portable Radiation Monitor, for fast, accurate measurement of radon levels.

Every bit as reliable as our previous cells, they have been designed to match the detection specifications of the AB-5 active cell detectors to maintain detection compatibility.

Backed by over 30 years of radon and thoron detection and measurement expertise, superior engineering, and world-class customer service, the Pylon AB6A and active cells provide radon detection you can depend on.

Key Features

High Sensitivity	Can detect low radon levels	Radiation Immunity	Immune to beta and gamma radiation
Versatile	Can be used for both Continuous and Grab sampling measurements	Stable	Insensitive to temperature and humidity changes
Simple Operation	Easy to use & transport		

Applications

When combined with the Pylon AB6A radiation monitor, these active cells can be used for:

PYLON

- Radon/Thoron Analysis
- Autonomous Continuous Monitoring
- Residential Monitoring
- Industrial Monitoring
- Environmental Monitoring
- Radioactive Site Monitoring
- Mining / Ore Processing
- Mineral Exploration
- Entry Point Testing (Radon Sniffing)
- Meteorological Studies
- Geological Studies
- Education
- Building Materials Research
- Health Protection

… And More

Lucas ZnS(Ag) scintillation cells are frequently used to measure radon gas. When radon decays into its daughter products, it gives off an alpha particle. When the alpha particle strikes the ZnS (Ag) scintillator that coats the inside of the cell, the scintillator gives off a photon of light. This photon is detected, converted to an electrical pulse, and amplified by the photomultiplier tube (PMT) in the monitor. The monitor further amplifies the pulse, discriminates out false pulses, and counts the number of pulses in periods of time. With other factors, this provides a measure of the radon that is present in the sample.

Technical Specifications

GENERAL

Radiation Detected:	Alpha
Scintillator:	ZnS(Ag)
Alpha Energy Range:	4.5 to 9 MeV
Accuracy [1]:	± 4%
Calibration [2]:	Upon Request
Maximum Flow Rate [3]:	10 l/min
Connectors:	Quick Connect Fittings
Mating Connectors:	Swagelok B-QC4-S-4HC
Primary Construction Material:	Aluminum

DETECTION SPECIFICATIONS

600A	
Lowest Activity Detectable:	27.4 Bq/m^3 (0.74 pCi/l)
Sensitivity:	0.037 $cpm/Bq/m^3$ (1.36 cpm/pCi/l)
Active Volume:	272 ml (9.2 oz. [US Liquid])
610A	
Lowest Activity Detectable:	48.1 Bq/m^3 (1.30 pCi/l)
Sensitivity:	0.021 $cpm/Bq/m^3$ (0.76 cpm/pCi/l)
Active Volume:	154 ml (5.2 oz. [US Liquid])

ENVIRONMENTAL

Operating Temperature Range:	0 to +50 °C (32 to +122 °F)
Storage Temperature Range:	-20 to +75 °C (-4 to +167 °F)
Relative Humidity Range:	0 to 90 % (Non-Condensing)

DIMENSIONS

600A	
Diameter:	6.1 cm (2.4 in.)
Height:	19.7 cm (7.75 in.)
Weight:	359 g (0.8 lb.)
610A	
Diameter:	6.1 cm (2.4 in.)
Height:	14.5 cm (5.7 in.)
Weight:	324 g (0.7 lb.)

1 At a 1σ Confidence Level.

2 Active cells are tested on a sampling basis. Custom calibrations are available.

3 For Continuous sampling, 0.5 l/min is recommended.

Ordering Information:

Model 600A Large Active Cell: Order part number 7100180.

Model 610A Small Active Cell: Order part number 7100190.

Values are nominal and based on new units.
Specifications subject to change without notice.

Contact a Representative

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