Field Measurement of Residual Radiation	SSFL SOP 7 Revision: 0 Date: April 2012

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1.0 Objective

The objective of this technical standard operating procedure (SOP) is to define the techniques and the requirements for the detection of residual radiation in the breathing zone and in soil at the Santa Susana Field Laboratory (SSFL). The Department of Energy (DOE) surface contamination criteria are also defined herein with footnotes which reflect acceptable approaches for demonstrating achievement of such criteria.

2.0 Background

2.1 Definitions

MicroR detector–A portable, hand-held scintillation counter that measures gamma radiation in air. Although measurements are typically made about one meter above the ground surface, such sodium iodide scintillation detectors can also be used qualitatively measure radiation emitted from soil samples and soil cores. In this instance the detectors will be held about 0.5 to 1 inch above the samples. When used to evaluate soil sample activity, measurements will be compared against background count rates for the same material taken in a consistent manner (i.e., 0.5 to 1 inch above soil material). Background is established by taking measurements in an area that produced count rates that are relatively low and uniform.

Dual Phosphor Alpha Beta Scintillator–A portable, hand-held field radiation survey instrument that may detect alpha and beta emissions and, with proper calibration, can measure gamma emissions.

2.2 Associated Procedures

- SSFL SOP 1, *Procedures for Locating and Clearing Phase 3 Samples*
- SSFL SOP 2, *Surface Soil Sampling*
- SSFL SOP 3, *Subsurface Soil Sampling with Hand Auger*
- SSFL SOP 4, *Direct Push Technology (DPT)Sampling*
- SSFL SOP 5, *Backhoe Trenching/Test Pits for Sample Collection*
- SSFL SOP 9, *Lithologic Logging*

2.3 Discussion

Radiation screening of soil samples and ambient air is necessary because of the prior use of Area IV for nuclear research. Radiation measurement data will be used pursuant to health and safety monitoring to determine if radiation exposure rates for field personnel in a work area is acceptable or if additional personal protective equipment or exposure limitations are necessary for field personnel. In addition to health and safety monitoring, radiation monitoring will be used to screen surface and subsurface soil and sediment samples for levels above background. Background readings are important because they provide a point of departure for elevated readings.

Two types of instruments will be used to measure residual radiation: the MicroR gamma detector and Dual Phosphor alpha/beta detector.

2.3.1 MicroR Operation

The MicroR detector is a scintillation meter used to measure low levels of gamma radiation. Although sodium iodide detectors can be set up to operate as a single channel analyzer, thereby reporting a specific radionuclide, the instruments for this project will be set up to report all gamma emissions, irrespective of radionuclide. The instrument has a speaker which provides an audible measure of the radiation emitted, as an audible click. The rate at which the clicks occur allows real-time monitoring of the strength of the radiation sources. Readout is generally in terms of microroentgens per hour (μR/hr).These instruments are energy dependant, commonly over-responding by as much as a factor of 8 or more for lower energy gamma emissions and under-responding by about 20 percent for cobalt-60.

2.3.2 Dual Phosphor Alpha Beta Scintillation Operation

For this project a Model 43-89 Dual Phosphor alpha/beta scintillation detector will be primarily used to detect alpha/beta emissions.

Although these detectors can also detect alpha emissions, alpha particles generally have a range of about an inch or less in air with relatively few able to penetrate the detector window such that they are counted. Alpha/beta detectors are generally calibrated to the gamma emissions of cesium-137 with instrument response being energy dependent. Beta efficiency also varies with energy such that 4 pi efficiency ranges from about 13 percent to 50 percent for beta particles with average energies of 50 and 550 kiloelectron volts (keV), respectively. If the instrument has a speaker, the pulses also give an audible click. The readout can be displayed in multiple different units (e.g., roentgens per hour (R/hr), milliroentgens per hour (mR/hr), rem per hour (rem/hr), millirem per hour (mrem/hr), and counts per minute (cpm)) when the control switch is in the "Ratemeter" position. Alpha/beta probes including, the pancake type, are commonly used with a variety of different hand held scalers/ratemeters for contamination measurements. Given the energy dependence of the instruments and their variable response to different types of radiation, radiation control/health physics personnel should be consulted if any activity exceeding instrument background is detected.

3.0 Responsibilities

Field Team Leader–The field team leader (FTL) is responsible for ensuring that field personnel conduct field activities in accordance with this SOP and the Field Sampling Plan [FSP] Addendum.

Site Health and Safety Technician–The person who will use field screening instruments to monitor all field activities for VOCs and radiological contaminants and pre-shipment sample coolers. This person is a trained radiological technician who works under the guidance of Science Application International Corporation's (SAIC's) Certified Health Physicist (CHP).

Certified Health Physicist–The person who oversee radiation survey activities, confirm background levels, and provide field direction when background levels are exceeded per the Health and Safety Plan.

4.0 Required Equipment

- Ludlum Model 19 or Model 192 Micro R Detector (or equivalent)
- Ludlum Model 43-89 Dual Phosphor Alpha/Beta Scintillation Detector (or equivalent)[1]
- Site-specific plans (i.e., FSP Addendum)
- Health and safety plan (HASP)
- Field logbook
- Waterproof black ink pen
- Personal protective clothing and equipment

5.0 Determination of Radiation Background

As set forth in the HASP (health and safety plan monitoring and action levels) and for the selection of soil sample intervals (SSFL SOP 2, 3, 4, and 5), background radiation levels for various media will be established prior to soil sampling. Because radiation levels vary based on composition of the media and multimedia that will effect radiation measurements at the site, the following background radiation levels will be developed initially at the site.

- Unconsolidated soil
- Bedrock

[1] Ludlum Model 2360, Ludlum Model 26

- Concrete slab/rubble
- Asphalt

Additional media may be added as it is encountered in the field. Background of these media will be established using the following procedure.

1. Ensure instrument is functioning properly and check source readings are acceptable per requirements of this SOP.
2. Demarcate background radiation SAMPLE AREA for each media with wooden Stakes. The Area IV background survey location established by EPA will serve as a starting point. Minimum requirements for the background SAMPLE AREA is as follows:
    a. 20 square feet of surface area
    b. made up of 80% intended media
    c. area does not consist of imported fill or debris
    d. area is absent of contamination (identified by visually inspection, and from EPA HSA, EPA gamma surveys, EPA soil sample results, RFI and Co-located Chemical data)
3. Obtain and Record GPS coordinates of SAMPLE AREA
4. Using appropriate radiation instrument (Micro R Meter Model 19/192, Dual Phosphor Alpha/Beta Detector Model 43-89) collect 10 gamma, alpha, and beta measurement about 0.5 to 1 inch above the media, equally distribute throughout the SAMPLE AREA. Each measurement will be at least 1 minute in duration.
5. Record the ten radiation measurements in log book.
6. Following collection of background measurements, ensure instrument is functioning properly and check source readings are acceptable per this SOP.
7. Discuss readings with site Certified Health Physicist (SAIC) for review and receive approval of background radiation level.
8. The Certified Health Physicist will provide approved background radiation level for the media to DOE and CDM Smith. This will include background level, mean, and standard deviation.
9. CDM Smith FTL will record the Certified Health Physicist’s recommendations and discuss the background action level with all field personnel as part of safety briefings.
10. Following establishment of, and periodical renewal of background readings throughout project, background radiation levels will be discussed during project meetings and daily tailgate safety meetings.

6.0 Procedures

6.1 MicroR Detector

Background Gamma Scan

1. Prepare the instrument and check batteries. The meter needle should move to area on scale marked battery, indicating the batteries are good.
2. Measure background radiation level away from sample and source area. Measure the background radiation for approximately 60 seconds to allow determination of the range and relative mean background exposure rates and write

down the readings. Note that background commonly ranges from about 5 to 20 µR/h, but can be higher as a result of increased elevation or higher concentrations of naturally occurring radioactive materials. In addition, it is often necessary to reevaluate background for different areas within the site. Upon completion of background determination, verify proper instrument operation using a National Institute of Standards and Technology (NIST) traceable check source to confirm proper instrument operation.

Surface Soil Gamma Scan

1. Beginning at the highest scale, proceed to lower scales until a reading is encountered. Set the instrument selector switch to the most sensitive range of the instrument. Holding the probe approximately 0.5 to 1 inch from the surface soil sample, move the detector slowly (about 1 inch per second) over the core and/or sample being evaluated with the detector parallel to the length of the core.

2. Do not let the probe touch anything and try to maintain a constant distance.

3. Areas that register more than background levels may be considered contaminated and a health physicist should be consulted.

6.2 Dual Phosphor Alpha/Beta Scintillation Detector

Background Alpha/Beta Scan

1. Prepare the instrument and check batteries. The meter needle should move to area on scale marked battery, indicating the batteries are good. Measure background radiation level away from source area.

2. Measure the background radiation at 0.5 to 1 inch above the media for ten 2-minute counting periods and record each of the readings. Background commonly ranges from about 5 to 20 µR/h but can be higher as a result of increased elevation or higher concentrations of naturally occurring radioactive materials.

3. Obtain ten 1-minute source activity measurements using a NIST traceable source of the appropriate beta energy.

4. Upon completion of the background and source efficiency counts, input the associated data into the spreadsheet provided to determine parameter limits (e.g., background and source efficiency within 20 percent of the mean). Subsequent counts of both background and source efficiency should be performed daily before instrument use, at the end of each duty day, and any time that instrument operation is questionable.

Soil Sample Beta Scan

1. Set the instrument selector switch to the most sensitive range of the instrument.

2. Holding the probe approximately 0.5 to 1 inch from the sample and move the probe slowly (about 1 inch per second). (***Note***: Alpha emissions are reliably detectable only with the detector as close as practicable to the item being surveyed. In addition, it should be noted that variation in beta background can preclude the ability to detect alpha emissions at levels prescribed in 10 CFR 835, Appendix D.)

3. Do not let the probe touch anything and try to maintain a constant distance.

4. Areas that register more than background level may be considered contaminated and a health physicist should be consulted.

Surface Contamination Scanning

In addition, every sample, piece of equipment, and container of material used at the site and/or that leaves the site will be surveyed and results will be used to document that residual total and removable surface contamination are compliant with criteria contained in Appendix D, 10 CFR 835. I

Surface Contamination Values[1] in dpm/100 cm^2 Radionuclide	Removable [2, 4]	Total (Fixed + Removable) [2, 3]
U-nat, U-235, U-238, and associated decay products	1,000[7]	5,000[7]
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	500
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above [5]	1,000	5,000
Tritium and STCs [6]	10,000	See Footnote 6

1. The values in this appendix, with the exception noted in footnote 6 below, apply to radioactive contamination deposited on, but not incorporated into the interior or matrix of, the contaminated item. Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides apply independently.

2. As used in this table, disintegrations per minute (dpm) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

3. The levels may be averaged over one square meter provided the maximum surface activity in any area of 100 cm^2 is less than three times the value specified. For purposes of averaging, any square meter of surface shall be considered to be above the surface contamination value if: (1) from measurements of a representative number of sections it is determined that the average contamination level exceeds the applicable value; or (2) it is determined that the sum of the activity of all isolated spots or particles in any 100 cm^2 area exceeds three times the applicable value.

4. The amount of removable radioactive material per 100 cm^2 of surface area should be determined by swiping the area with dry filter or soft absorbent paper, applying moderate pressure, and then assessing the amount of radioactive material on the swipe with an appropriate instrument of known efficiency. (Note—The use of dry material may not be appropriate for tritium.) When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area shall be based on the actual area and the entire surface shall be wiped. It is not necessary to use swiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

5. This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched.

6. Tritium contamination may diffuse into the volume or matrix of materials. Evaluation of surface contamination shall consider the extent to which such contamination may migrate to the surface in order to ensure the surface contamination value provided in this appendix is not exceeded. Once this contamination migrates to the surface, it may be removable, not fixed; therefore, a “Total” value does not apply. In certain cases, a “Total” value of 10,000 dpm/100 cm^2 may be applicable either to metals, of the types which form insoluble special tritium compounds that have been exposed to tritium; or to bulk materials to which particles of insoluble special tritium compound are fixed to a surface.

7. These limits only apply to the alpha emitters within the respective decay series.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59688, Nov. 4, 1998; 72 FR 31940, June 8, 2007; 74 FR 18116, Apr. 21, 2009]

7.0 Restrictions/Limitations

Micro R and Dual Phosphor detectors are principally used for the detection of presence of radionuclides above background, not measurement devices. They are prone to breaking if the thin entrance window (found on pancake and end-window designs) is punctured. This can easily occur if the window comes in contact with a variety of objects (such as a blade of grass, paper clip, nail, and paint flecks). Once the window is broken the instrument ceases to operate and must, therefore, be returned for repair and calibration.

8.0 References

Integrated Environmental Management, Inc., 1998, *Measuring Radioactivity*

Oak Ridge Institute for Science and Education and Radiation Emergency Assistance Center/Training Site (REAC/TS), 1992, *Using a Typical Geiger-Mueller (GM) Counter to Survey*

Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection

DOE Standard Radiological Control, DOE-STD-1098-2008 with change 1 dated May 2009

DOE Order 426.2, Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities, 21 April 2010

DOE Standard 1107-97 with Change 1 dated November 2007, Knowledge, Skills, and Abilities for Key Radiation Protection Positions

Ludlum Measurements, Inc. Operators Manuals for Model 2241 Survey Meter with Model 19/192 Detector

Ludlum Measurements, Inc. Operators Manuals for Model 43-80 Alpha/Beta Scintillator