OP-5010

RADIATION SAFETY MANUAL

FOR

NRC MATERIALS LICENSE 06-30556-01

Revision 4.0
February 2021

Level of Use:
Information Use

APPROVALS	
President	*R. Flowers, PMP, CHMM*
Quality Assurance	*S. Liddy, CSP*
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History of Revisions		
Revision	**Month-Year**	**Description**
0	January 2000	Initial issue.
1.0	May 2010	Revised to incorporate Cabrera management organizational changes and clarifications to various sections.
2.0	April 2014	Revised to incorporate Cabrera management organizational changes and clarifications to various sections.
3.0	Jan 2021	Manual generally revised to reflect August 2020 license renewal action based on NUREG-1556 Vol. 18, Rev. 1; replace Reg Guide 1.86 clearance levels with NUREG 1575 (MARSAME) Appendix E Table E. OP# assigned.
4.0	Feb 2021[1]	Revised Section 19 to clarify reason for not needing a financial assurance for decommissioning. Editorial Corrections in Section 5.4 & 5.5.
[1] The most current listed revision to this manual is considered effective upon cover sheet approval signatures of the Radiation Safety Officer and Company Official AND posting of the complete revision to the Cabrera Controlled Document Repository. The RSO ensures the RSM is posted to the CCDR after briefing personnel with current responsibilities related to the Radiation Safety Program on changes.		

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1.0 PURPOSES FOR WHICH LICENSED MATERIAL WILL BE USED

Cabrera Services Inc (Cabrera) provides decontamination services, and performs site surveys, remediation activities, decontamination activities, waste characterization, waste packaging and shipment in conjunction with these services. Use, possession, and "possession incident to performing commercial services" on unsealed radioactive materials will occur incident to performing the following activities:

- Decontamination, decommissioning, and remediation of facilities and grounds, equipment, and containers
- Site characterization
- Solidification and treatment of wastes
- Packaging for transport
- Transport in packages or containers approved for use under the provisions of 10 CFR Part 71, for transfers to licensees authorized to receive the materials, in accordance with the terms and conditions of licenses issued by the U.S. Nuclear Regulatory Commission (NRC) or Agreement States; and
- As calibration sources and reference standards for operational testing of radiation detection equipment.

If a customer also holds a license issued by the NRC or an Agreement State, the RSO shall establish a written agreement between with the customer specifying which licensed activities shall be performed under the customer's license and supervision, and which licensed activities shall be performed under Cabrera's supervision pursuant to this license. The agreement should include a commitment by both parties to ensure safety, and any commitments by the licensee to help the customer clean up the temporary job site if there is an accident.

2.0 MANUAL PURPOSE & APPLICABILITY

This Radiation Safety "Manual" (RSM) is the primary reference tool for implementation of the Cabrera Radiation Safety Program and; is used in conjunction with specific license conditions and applicable regulations, governmental guidance, industry standards, and good health physics practices established in Cabrera policies and procedures to ensure effective radiation safety program implementation.

This manual applies to all use and possession of radioactive materials conducted under NRC General License or Service Providers Materials License #06-30556-01.

This manual may also be used for other use and possession of radioactive materials at temporary job sites outside NRC jurisdiction. In these cases, application of this RSM (with any noted exceptions) must be obtained from the appropriate governing authority prior to use. As an example, this acceptance may be obtained through record of correspondence or acceptance of site-specific work plan that references this RSM and/or specific procedures.

3.0 NUCLEAR SAFETY CULTURE

Cabrera is committed to establishing and maintaining a work-place culture as prescribed by the NRC in 76 FR 34773 “Safety Culture Policy Statement”, Cabrera’s commitment emphasizes safety and quality over competing goals to ensure the radiation safety of workers, public and environment. To that end, Cabrera Management commits to promote safety in communications and provide resources and leadership that promoted a safety conscious and healthy work environment where:

- activities involving radioactive materials are planned and controlled.
- where individuals are trusted, respected, accountable for their own safety, and welcome to raise associated concerns without fear of retaliation, intimidation, harassment, or discrimination.
- where individuals avoid complacency and continuously challenge existing conditions and activities in order to identify discrepancies that might result in error or inappropriate action.
- where issues potentially impacting safety are promptly identified, fully evaluated, and promptly addressed and corrected commensurate with their significance.
- where opportunities to learn about ways to ensure safety are sought out and implemented.

To ensure effective Nuclear Safety Culture implementation, a designated Company Official (CO) will act as the overall “Manager” with authority and responsibility to provide resources and oversite, as needed to ensure effective radiation safety program implementation.

The CO designates the Radiation Safety Officer (RSO) responsible for effective implementation of the Radiation Safety Program (subject to NRC approval of designation).

The RSO designates and assigns tasks to Authorized Users (AU) and Radiation Safety Support personnel to assist in promoting safe practices that result in reduced dose to personnel and minimizing of any environmental impacts from Cabrera temporary job site activities.

Radiological Workers and Ancillary personnel receive nuclear safety specific training and work under controls established by the RSO, as appropriate for their job assignment and proximity to licensed materials/activities.

ALL personnel working in proximity to radioactive materials and under any established Cabrera Radiation Safety Program have “Stop Work” authority for any immediate safety concern including, radiological safety concerns (e.g., breakdowns in controls, required monitoring not being conducted, unsafe worker practices, potential environmental releases, etc.). Radiological-related concerns are first addressed at the field level by the AU or Rad Safety Support Staff then, if necessary, by the RSO who consults as-needed with the CO prior to restarting associated radioactive material use(s).

4.0 DEFINITIONS & ACRONYMS

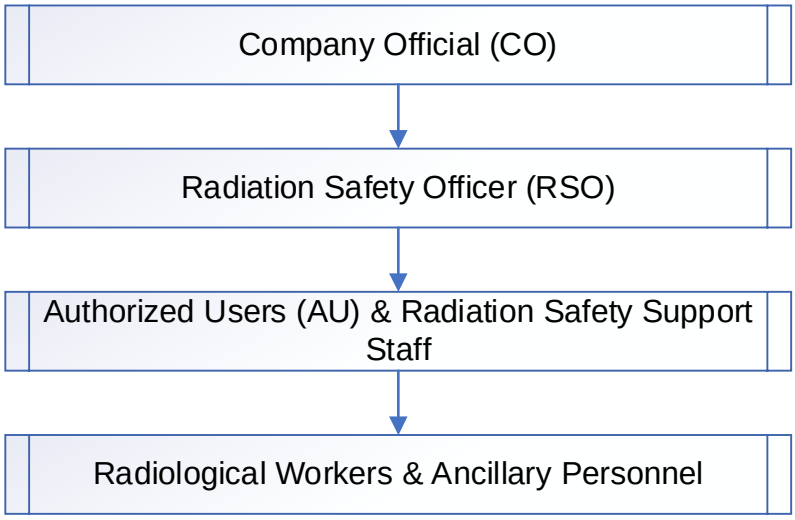
For NRC licensed activities, Cabrera generally adopts the NRC definitions of terms and usage of acronyms related to radiation safety from Title 10 Code of Federal regulations and applicable regulatory guidance. Key definitions related to radiation safety are found in 10 CFR § 20.1003. Other definitions/acronyms utilized by the NRC such as NUREG-0544, Revision 5 may be used and; Cabrera may adopt other definitions/acronyms provided they do not alter/contradict an applicable term used by NRC.

For activities outside NRC jurisdiction, alternate definitions and acronyms may be used as appropriate to the applicable governing authority.

5.0 INDIVIDUALS RESPONSIBLE FOR RADIATION SAFETY PROGRAM

The following organization chart represents the reporting and accountability structure of the Cabrera Radiation Safety Program:

Cabrera Services Radiation Safety Organization



5.1 Company Official (CO)

The Company Official (CO) is a member of Cabrera Management with authority and responsibility to expend company funds, as needed, to ensure the RSO has the resources needed to implement an effective radiation safety program. The CO also provides executive management level oversight of radiation safety program implementation.

The Company Official is currently the President/Chief Operating Officer of Cabrera. The President may designate a Vice President (or equivalent Senior Management Level) to act as the CO on their behalf.

The CO appoints individuals who meet the qualifications specified in 10 CFR § 30.33(a)(3), 10 CFR § 40.32(b), and 10 CFR § 70.22(a)(6) to the position of RSO.

If there is a change in the current RSO's employment or long-term status (i.e., absent more than 30 consecutive calendar days), the CO shall ensure the NRC is notified via formal amendment request that includes name and qualifications of the temporary/permanent replacement RSO as soon as possible typically, within 30 days of the change.

5.2 Radiation Safety Officer (RSO)

The Radiation Safety Officer is responsible for the radiation safety program and for ensuring that radiation safety activities are performed safely according to approved policies, procedures and that all regulatory requirements are met. The RSO is available for emergencies and can respond to a temporary job site within 24-48 hours, as needed.

The RSO is designated by and reports to the Cabrera designated CO.

The responsibilities of the RSO may not be transferred to other individuals. Many tasks and duties associated with managing the program may be assigned or delegated to other qualified individuals; however, the responsibility for these tasks and duties remains with the RSO.

An Authorized User or other qualified member of the radiation safety staff may occasionally "fill in" for the RSO when the RSO is away for short periods of time (e.g., professional conferences, vacation, illness, etc. with a duration of up to 30 calendar days). During absences and to the extent practicable, the RSO should be available for phone/e-mail consultation.

5.3 Authorized Users (AU)

A Cabrera Authorized User independently uses, or oversees usage, of radioactive materials at a temporary jobsite. The AU is responsible for ensuring that radioactive materials are handled and used safely and in accordance with NRC regulations and the terms and conditions of the NRC license.

Before using or overseeing the use of radioactive material, personnel designated as an AU will have received appropriate training or demonstrate equivalent qualification as described in Section 6.1.

AUs report to the RSO on Radiation Safety related matters and are formally designated by the RSO after review of credentials.

5.4 Radiation Safety Support Staff

Radiation Safety Support Staff are made up of a combination of radiation protection technicians ("Rad Techs") and subject matter experts who work under the direct oversight of the RSO or AU and assist with radiation safety program implementation and health physics technical matters. The RSO determines assignment of support staff tasks & duties based on the level of skill required and review of subject-matter qualifications. Radiation Safety Support personnel receive radiation safety training per Section 6.2.

5.5 Radiological Workers and Ancillary Personnel

Radiological workers and other ancillary personnel who routinely enter Restricted Areas or work in proximity with radioactive materials are responsible for their own radiation safety. This responsibility is satisfied by individual participation in required radiological training at required frequencies, and consistent compliance with radiation safety related policies, procedures, permits, postings, and associated written/verbal direction from the RSO, AU, or designated member of the Radiation Safety Support Staff who is providing radiation safety oversight at a temporary job site. Radiological workers and ancillary personnel receive radiation safety training per Section 6.2.

6.0 TRAINING

Before working in the vicinity of licensed materials, personnel will have successfully completed training commensurate with assigned duties, as follows:

6.1 Authorized Users

Before independently using or overseeing the use of licensed material by others, personnel designated as authorized users will:

- Receive the training described in NUREG-1556, Volume 18, Revision 1, Appendix D “Criteria for Acceptable Training and Experience for Authorized Users” **OR**

- Demonstrate equivalent qualification by having at least one year of hands-on work experience supporting implementation of a radiation safety program at a facility or job site commensurate with the scope of NRC Materials License No. 06-30556-01 **AND** review the current license terms, conditions and applicable regulations **AND** review the radiation safety program **AND** produce documentation for review and acceptance by the RSO that demonstrates current/past evidence of one or more of the following:
  - Designation as an RSO or AU on an NRC or Agreement State License
  - Designation as a RadCon Manager or qualified as a RadCon Technician for a Department of Energy Activity
  - Certification by the American Board of Health Physics
  - Registration by the National Registry of Radiation Protection Technologists
  - Bachelors (or higher) Degree in Nuclear/Environmental Sciences or related Scientific Discipline
  - Associates Degree (or higher) in Health Physics/Radiation Protection Technology
  - Department of Defense Health Physicist, Radioactive Waste Broker, Engineering Lab Technician, Radiological Controls Technician or equivalent
  - Department of Energy Radiological Controls Technician Training
  - Radiation Safety Program/Officer related training of at least 40 hours

6.2 Other Individuals

Individuals who frequently access Restricted Areas or, work with radioactive material under the on-site oversight of an AU or, are likely to receive during employment an occupational dose in excess of 100 mrem (1 mSv) shall be:

(1) Kept informed of the storage, transfer, or use of radiation and/or radioactive material.
(2) Instructed in the health protection problems associated with exposure to radiation and/or radioactive material, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed.
(3) Instructed in, and required to observe, to the extent within the workers control, the applicable provisions of Commission regulations and licenses for the protection of personnel from exposure to radiation and/or radioactive material.
(4) Instructed of their responsibility to report promptly to the licensee any condition which may lead to or cause a violation of Commission regulations and licenses or unnecessary exposure to radiation and/or radioactive material.
(5) Instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation and/or radioactive material.
(6) Advised as to the radiation exposure reports which workers may request pursuant to 10 CFR § 19.13.

7.0 FACILITIES AND EQUIPMENT

Services provided by Cabrera will only be performed at temporary job sites; Cabrera shall not take possession of radioactive materials from temporary job sites.

Cabrera owned sources and equipment containing radioactive materials requiring specific license to possess shall not be returned to a Cabrera facility; contact the RSO for further guidance on such materials.

8.0 SAFE USE OF RADIONUCLIDES

8.1 Operating & Emergency Procedures

To ensure the safety of personnel and protection of the environment, possession and use of radioactive materials SHALL be performed in accordance with this Radiation Safety Manual (RSM) and operating/emergency procedures that provide additional radiation protection guidance and are approved by the CO and RSO. Changes to this manual or other radiological operating/emergency procedures that reduce the effectiveness of the overall Radiation Protection Program shall be submitted to NRC for concurrence prior to implementation.

The controlled (i.e., current and approved) versions of all Cabrera Operating Procedures (including this manual) are maintained in an organized and secure electronic document repository referred to as the Controlled Copy Document Repository (CCDR).

Signature approval of the CO and RSO is required for the initial issuance and subsequent revision to this manual and any separately controlled procedures used to support implementation of this RSM. Existing procedures that were not previously approved by signature of both the CO and RSO shall be reviewed, approved by signature, and posted to the CCDR prior to first-use in support of this RSM (Rev. 3).

Personnel affected by revisions to this RSM or associated procedures shall be briefed by the RSO changes, prior to posting the revision to the CCDR.

Other documents (e.g., equipment operating manuals, computer software, job-aids, internet resources, etc.) may be used to support effective program implementation at the discretion of the RSO.

Unless specifically noted, all Cabrera forms are provided as examples for use in implementing the radiation safety program. Alternative form versions (including electronic) may be used at the discretion of the RSO provided key information is maintained.

8.2 Emergency Plan

Based on current license possession limits, Cabrera is not required to establish an emergency plan. Before taking possession of licensed material at a temporary job site in quantities requiring an emergency plan, the licensee shall amend the license to increase possession and, either:

- Obtain NRC approval of an evaluation demonstrating that an emergency plan is not required pursuant to 10 CFR § 30.32(i), 10 CFR § 30.72, or
- Submit written confirmation to the Regional Administrator, U.S. Nuclear Regulatory Commission, Region I, ATTN: Director, Division of Nuclear Materials Safety, 2100 Renaissance Boulevard, Suite 100, King of Prussia, Pennsylvania 19406, that the licensee personnel have been trained and will follow the provisions of an existing emergency plan approved by the NRC or an Agreement State for the temporary job site.

9.0 LEAK TESTS

Cabrera procedures for leak testing will be based on guidance found NUREG-1556, Volume 18, Revision 1, Appendix G “Model Leak Test Program.”

10.0 MATERIAL RECEIPT AND ACCOUNTABILITY

Cabrera will ensure accountability (receipt, transfer, disposal) of licensed materials in possession at all times by implementing procedures that govern radioactive material control & accountability.

Cabrera procedures for receipt/opening of radioactive materials packages will address all requirements of 10 CFR § 20.1906.

Before transferring aggregated Category 1 or Category 2 quantities of radioactive material listed in Appendix A to 10 CFR Part 37, Cabrera will use NRC's license verification system to verify that the recipient licensee is authorized to possess the radioactive material.

Cabrera will preplan, coordinate and provide advance notification of shipment of Category 1 quantities of radioactive material and coordinate shipment of Category 2 quantities of radioactive material listed in Appendix A to 10 CFR Part 37.

Physical inventories will be conducted at intervals not to exceed 6 months, to account specifically licensed material and devices received and possessed under the license. Records of inventory shall be maintained for a period of 3 years from the date of each inventory, and shall include the radionuclides, quantities, manufacturer's name and/or model numbers, and the date of the inventory.

Cabrera will comply with the NSTS reporting requirements as described in 10 CFR § 22.2207.

Cabrera will control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage in accordance with 10 CFR § 20.1802, "Control of material not in storage."

11.0 RADIATION MONITORING INSTRUMENTS

Cabrera will maintain sufficient instruments to support work at temporary job sites and to respond to emergencies. Table 1 presents the minimum equipment Cabrera will maintain to conduct required radiological surveys (one of each type):

Table 1: Radiation Monitoring Instruments

Make and Model Number	Description	Typical Range of Use	Purpose
Ludlum Model 2929/ 3030; Protean WPC-9550 or equivalent	Scintillation-type or Gas-Flow Proportional Field Laboratory Counter	0 to 10,000 counts per minute (cpm) (alpha-beta)	Gross alpha-beta counting of primarily smears and air filters
Thermo-Bicron MicroREM Meter; Ludlum Model 19 or equivalent	Hand-held Gamma Dose/Exposure Rate meter	2 to 5,000 µR/hr	Personnel monitoring, dose rate surveys
Ludlum Model 3 or 12 with Ludlum Model 44-9; Ludlum Model 2224 with Ludlum Model 43-93 or equivalent	Hand-held Scintillation/ Geiger-Muller detector	40 to 10,000 cpm (alpha-beta)	Personnel monitoring, contamination surveys

Cabrera will implement and conduct calibration of radiation survey meter in accordance with Appendix F of NUREG–1556, Volume 18, Revision 1, "Consolidated Guidance About Materials Licenses: Program-Specific Guidance About Service Provider Licenses."

Additional instruments are procured as directed by the RSO to support effective program implementation. Ready access to back-ups should be maintained to extent practicable; customer-maintained instrumentation may also be used with approval from the RSO.

12.0 SURVEYS

Cabrera will conduct surveys and maintain contamination levels in accordance with the survey frequencies and contamination levels published in Section 8.10.4 of NUREG-1556, Volume 18, Revision 1. "Consolidated Guidance About Materials Licenses: Program-Specific Guidance About Service Provider Licenses."

12.1 Unrestricted Release of Materials, Tools, and Equipment

Items brought into posted Contamination Areas, Airborne Radioactivity Areas, or come into direct contact with unsealed radioactive materials present may become cross-contaminated and are considered potentially impacted requiring assessment prior to release from radiological controls.

During assessment, the RSO, or on-site designee, may exclude items/portions of items from clearance survey when the use history is well-understood and there is no reasonable potential for the item/portion in question to have become contaminated with residual radioactivity.

For non-excluded items requiring survey for clearance, surveys will be based on methodologies prescribed in NUREG-1575 (MARSAME guidance) with screening levels for clearance based on NUREG 1575 (MARSAME) Appendix E Table E.3, reproduced here for quick-reference purposes:

Table 2: Screening Levels for Clearance

	Radiation	Total Surface Activity	Removable Surface Activity
Reactor Licenses	b-g	Non-detectable MDC 5/6 Bq/cm^2 (5,000 dpm/100 cm^2)	Non-detectable MDC 1/6 Bq/cm^2 (1,000 dpm/100 cm^2)
	a	Non-detectable MDC 1/60 Bq/cm^2 (100 dpm/100 cm^2)	Non-detectable MDC 1/300 Bq/cm^2 (20 dpm/100 cm^2)
Materials Licenses	b-g[1]	5/6 Bq/cm^2 (5,000 dpm/100 cm^2)	1/6 Bq/cm^2 (1,000 dpm/100 cm^2)
	a[2]	1/60 Bq/cm^2 (100 dpm/100 cm^2)	1/300 Bq/cm^2 (20 dpm/100 cm^2)

1. Except Sr-90, I-126, I-131, and I-133, where 1/6 Bq/cm2 and 1/30 Bq/ cm2 removable applies; and except I-125, and I-129 where 1/60 Bq/cm2 and 1/300 Bq/cm2 removable applies.
2. Except natural U, U-235, U-238, and associated decay products where 5/6 Bq/cm2 and 1/6 Bq/cm2 removable applies; and except transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, and Ac-227, where 1/60 Bq/cm2 and 1/300 Bq/cm2 removable applies.

13.0 MINIMIZATION OF CONTAMINATION

When designing facilities and developing procedures for their safe use, Cabrera will plan ahead and consider how to minimize radioactive contamination during operation, decontamination and decommissioning efforts, and radioactive waste generation in accordance with 10 CFR § 20.1406. Considerations include:

- Implementation of and adherence to good health physics practices in operations.

- Minimization of areas, to the extent practicable, where radioactive materials are used and stored.
- Maximization of the frequency of surveys, within reason, to minimize spread of contamination.
- Appropriate filtration of effluent streams.
- Use of non-porous materials for work or laboratory bench tops, flooring, etc.
- Ventilation stacks and duct work with minimal lengths and minimal abrupt changes in direction.
- Use of appropriate plumbing materials with minimal pipe lengths and traps.
- Minimization of the number of disposal sites (e.g., sinks) where liquid waste is disposed.

14.0 ALARA PROGRAM

Cabrera is committed to maintaining all doses within regulatory standards and As-Low-As-Reasonably-Achievable (ALARA).

The RSO ensures that ALARA principals and best practices are considered whenever working in proximity to radioactive materials; radiological operations are pre-planned, coordinated, and conducted to allow for implementation of effective strategies to minimize dose and control contamination to achieve ALARA goals.

Radiation Safety tracks radiation exposure status and adherence to posted written and oral radiological control instructions and procedures.

At a minimum, the RSO will ensure that formal “ALARA” dose reduction goals are established for temporary job sites where individual monitoring of internal or external dose is required by regulation.

ALARA reviews and briefings are informally conducted between Radiation Safety personnel and other affected personnel as part of day-to-day oversight of radiological work when dose reduction opportunities present themselves or workers themselves identify. Formal documented ALARA reviews & worker briefings will be conducted & documented when triggered, as noted in Table 3. Records of reviews are used to support work planning and permitting.

Cabrera’s ALARA supporting procedure provides the requirements and methods personnel will utilize for conducting ALARA reviews and briefings. This procedure applies to formal ALARA reviews and briefings conducted by radiation protection technicians (RPT), the RSO and the RSC. Records created from performing this procedure are used by project radiological safety personnel to document work evolution and maintain exposures ALARA. ALARA reviews for individual tasks at a client site are initiated based on risk factors determined by direct, contamination, and airborne exposures and work condition trigger levels, (refer to Table 3).

Table 3: Formal ALARA Job Review and Briefing Requirements

Anticipated Work Condition [a]	Conducts Review	Approves Review	Briefs Personnel
1. Any individual dose is expected to exceed 100 millirem (mrem) in a week.	AU/ RSO	RSO	See Note [a]
2. The collective dose for individually monitored workers exceeds 0.5 rem.			
3. Airborne exposures expected to exceed 12 Derived Air Concentration (DAC)-hours per week for any single individual.			
4. General area dose rates exceed 2 millirem per hour (mrem/hr).			
5. Work in a posted High Contamination Area			
6. Use of supplemental engineering controls (HEPA filter systems, glove bags, tents, and other similar devices) and radiologically required respiratory protection to reduce projected personnel doses below occupational standards.	These work conditions have non-readily determined risk factors associated with them and shall be reviewed and approved by the RSO in all instances.		
7. Installation, removal, or modification of temporary radiation shielding			

a. For work conditions involving one to ten times those quantities identified in items 1 through 4, an AU or other knowledgeable member of the Rad Safety Staff may conduct the briefing; the RSO shall conduct briefings when the 10x the review-briefing trigger values are expected or observed.

15.0 OCCUPATIONAL DOSE

Cabrera shall maintain occupational doses within regulatory standards. Cabrera will evaluate the dose its occupationally exposed individuals are likely to receive prior to allowing the individual to receive the dose (prospective evaluation) and will employ the use of dosimetry and bioassay measurements as required by 10 CFR § 20.1502. Cabrera will provide dosimetry processed and evaluated by a National Voluntary Laboratory Accreditation Program (NVLAP) accredited processor that is exchanged at a frequency recommended by the processor in accordance with the criteria in NUREG-1556, Volume 18, Revision 1, Section 8.10.6 “Occupational Dose.” Cabrera shall develop and implement OPs/work instructions and/or project-specific plans for bioassay analyses in accordance with NRC Regulatory Guide 8.34, Regulatory Guide 8.9, and NUREG/CR-4884, as applicable.

16.0 PUBLIC DOSE

Cabrera will provide documentation by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from the licensed operations do not exceed the annual limit for members of the public in accordance with the methods provided in NUREG-1556, Volume 18, Revision 1, Appendix I “Guidance for

Demonstrating that Individual Members of the Public Will Not Receive Doses Exceeding the Allowable Limits."

17.0 AUDIT PROGRAM

Audits and inspections shall follow the outline of the audit program in NUREG-1556, Volume 18, Revision 1, Appendix L "Suggested Service Provider Audit Checklist." Ongoing evaluation of the impact of recent RSM revisions/exceptions SHALL be included as a part of the audit checklist.

An independent auditor may conduct these reviews; at the same time, it does not relieve the RSO of the responsibilities to ensure that the reviews are conducted in accordance with applicable regulations. At a minimum, an audit of the RSP shall be performed annually. A qualified individual having no direct responsibility for the operation being audited shall be used to perform the annual audit in order to ensure unbiased and competent results. This annual audit shall be performed by an individual with at least two years of experience in applied health physics.

The intervals of audits and inspections will be frequent enough to ensure close communications and proper surveillance of individuals working with or around radioactive materials. These intervals will be based on the quantities, types, and use of radioactive materials and will be specified in project-specific plans (e.g., large quantities or volatile radioactive materials may be audited weekly, lesser risk activities may be audited monthly or at least once per project duration).

Audit and inspection reports shall be given to the RSO. Reports will include items requiring corrective actions and corrective follow-up actions will be documented.

Results of the audit and program reviews should be reported to the RSO and CO to allow for timely and aggressive remedial actions sufficient in scope to ensure compliance with NRC regulations and license conditions.

18.0 RECORDKEEPING FOR DECOMMISSIONING

Pursuant to 10 CFR § 30.35(g), 10 CFR § 40.36(f), and/or 10 CFR § 70.25(g), Cabrera shall maintain drawings and records important to decommissioning and to transfer these records to an NRC or Agreement State licensee before licensed activities are transferred. Furthermore, pursuant to 10 CFR § 30.51(f), 10 CFR § 40.61(f), and 10 CFR § 70.51(a) prior to license termination, Cabrera shall forward the records required by 10 CFR § 30.35(g), 10 CFR § 40.36(f), and 10 CFR § 70.25(g) to the appropriate NRC regional office or to assign the records to the appropriate NRC regional office before the license is terminated.

Decommissioning records are NOT required for temporary job site locations.

Records associated with decommissioning surveys performed as a service at client sites are typically provided to the client at the completion of contracted work after required reviews conducted per this RSM or specific work plan.

19.0 FINANCIAL ASSURANCE

With the exception of calibration sources and reference standards, possession of licensed material at each job site shall be limited to material originating from each site. Pursuant to 10 CFR § 30.11, 10 CFR § 40.14, 10 CFR § 70.14 and possession-related license conditions, Cabrera is exempted from the requirements of 10 CFR § 30.35, 10 CFR § 40.36, and 10 CFR § 70.25 to establish decommissioning financial assurance.

20.0 MAINTENANCE

In accordance with NUREG-1556, Volume 18, Revision 1, Section 8.10.9 “Maintenance,” service providers who perform maintenance as a commercial service to other licensees must maintain devices (e.g., survey instrument calibrators and self-shielded irradiators) according to the manufacturer’s written recommendations and instructions and Sealed Source Device registry, if applicable.

Cabrera does not normally provide maintenance services. Before entering maintenance services, Cabrera will implement and maintain procedures for conducting routine maintenance of devices according to each manufacturer’s (or distributor’s) written recommendations and instructions.

Cabrera will have the device manufacturer (or distributor) or other person authorized by NRC or an Agreement State to perform nonroutine maintenance of devices.

Cabrera will as obtain prior NRC approval, if OEM replacement parts cannot be used, for sealed source shielding, the source driving unit, or other electrical or mechanical component that could expose the source, reduce the shielding around the source, or compromise the radiation safety of the device or source.

21.0 TRANSPORTATION

Cabrera has established procedures OPs/work instructions and/or project-specific plans for transportation modeled after NUREG-1556, Volume 18, Revision 1, Appendix J “Transportation.”

22.0 WASTE MANAGEMENT

Cabrera plans to dispose of low-level radioactive waste (LLW) through transfer to an authorized recipient or to dispose of liquid scintillation media or animals containing low levels of H-3 or C-14, as authorized by 10 CFR § 20.2005. If waste management procedures are required, Cabrera will use the model waste procedures published in NUREG-1556, Volume 18, Revision 1, “Appendix M “Model Waste Disposal Program.”

OPERATING PROCEDURE

FOR

Unconditional Release of Materials and Equipment from Radiological Controls

OP-3802

(FORMERLY OP-004)

Revision 3.0
January 2021

Level of Use: Information Use APPROVALS	
President	*R. Flowers, PMP, CHMM*
Quality Assurance	*S. Liddy, CSP*
Health Physics	*M. Winters, CHP*
This procedure is the property of Cabrera Services Inc. and is considered approved and effective for the duration it is posted electronically to the Controlled Copy Document Repository.	

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History of Revisions		
Revision	**Month-Year**	**Description**
0	-	OP-004, Unconditional Release of Materials and Equipment from Radiological Control Areas - Initial issue.
1.0	July 2005	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices.
2.0	April 2013	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices.
3.0	January 2021	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Provides all new guidance on performing unconditional release surveys based on MARSAME guidance and surveys designed to identify residual radioactivity inconsistent with background instead of comparison with a regulatory action level above background. Renumbered OP-3802 to conform to 4-digit series as outlined in OP-2001.

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1.0 Purpose

This procedure establishes the process to assess residual radioactivity potential in materials & equipment used to support radiological work prior to release for unrestricted use from radiological controls at temporary job sites.

This procedure addresses assessment of items as “impacted or non-impacted”; methods to “exclude” specific items/surfaces from survey requirements; methods for planning and implementing MARSAME-based surveys to demonstrate impacted surfaces meet appropriately selected screening levels for clearance (SLC); document requirements and; approach to disposition the item(s) based on assessment outcome and cost-benefit analyses.

2.0 Scope/Applicability

This procedure applies to M&E specifically used during temporary job site activities conducted under a Cabrera RPP. Materials and equipment taken in Radiologically Controlled/Restricted Areas generally require “assessment” prior to unrestricted release. The assessment generally leads to “exclusion” of items that do not require survey due to residual surface radioactivity (AU/RSO determination); surveys for “clearance” of those impacted items that were not completely excluded potential and; disposition (i.e., decontaminate, dispose of as waste, release from radiological controls.)

This procedure may be used for existing M&E at client sites under very specific conditions and limitations that may require regulator concurrence; consult with the RSO prior to use of this procedure to support unrestricted release of existing material at client sites. The RSO shall review applicable license conditions or site plan requirements and determine if regulator pre-approval is required to use this procedure.

This procedure applies to M&E impacted by residual surface radioactivity, **NOT** volumetric radioactive material. If residual volumetric activity is suspected consult with the RSO for guidance on proper disposition of the M&E in accordance with stakeholder accepted criteria for the temporary job site or applicable license.

This procedure does **NOT** apply to personnel exiting RCAs established or controlled under a Cabrera radioactive materials license (refer to OP-3403, *Personnel Frisking and Decontamination*).

This procedure does **NOT** apply to survey and unconditional release of real property (unless called for by applicable regulator-accepted work control documents).

3.0 Definitions

3.1 Accessible Surface: A surface that can be easily reached or obtained for the purposes of performing a measurement or collecting a sample.

3.2 Ambient Radiation: Radiation currently present in surrounding area that may change with season, time, location, weather, and environmental conditions.

3.3 Background Radiation: Radiation from cosmic sources; naturally occurring

radioactive material including radon (except as a decay product of source or special nuclear material); and global fallout as it exists in the environment from the testing of nuclear explosive devices or from past nuclear accidents such as Chernobyl that contribute to background radiation and are not under the control of the licensee. “Background radiation” does not include radiation from source, byproduct or special nuclear materials regulated by the Nuclear Regulatory Commission (10 CFR § 20.1003).

3.4 Background Threshold Value (BTV): A not-to-exceed value estimating the upper boundary of a randomly collected data set representing a single statistical population (e.g., background).

3.5 Categorization: The act of determining whether M&E are impacted or non-impacted.

3.6 Classification: The act or result of separating impacted M&E or survey units into one of three designated classes. The process of determining the appropriate level of survey effort based on estimates of activity levels and comparison with SLC.

3.7 Critical Value (SC): The minimum measured value required to give a specified probability that a positive (non-zero) amount of radioactivity is present in the material being measured.

3.8 Difficult to Access Surface: A surface that is not measurable without preparation. Preparation may be relatively simple (e.g., cleaning), complicated (e.g., disassembly), or not practicable (e.g., complete destruction of the object).

3.9 Disposition: The future use, fate, or final location for M&E.

3.10 Gray Region: The range of radionuclide concentrations of radioactivity between the discrimination limit and the SLC where the consequence of decision errors is relatively minor.

3.11 Impacted: Materials and equipment with a reasonable potential to contain radionuclide concentrations or radioactivity above background. Impacted items require clearance surveys prior to release from radiological controls.

3.12 Lower Bound of the Gray Region (LBGR): The radionuclide concentration or level of radioactivity corresponding with the lowest value in the range where the consequence of decision errors is relatively minor. For unconditional release surveys the LBGR is background or zero.

3.13 Non-impacted: Materials and equipment where there is no reasonable potential to contain radionuclide concentrations or radioactivity above background. Non-impacted items are typically excluded from clearance surveys prior to release from radiological controls.

3.14 Radiologically Controlled Area (RCA): Synonymous with “Restricted Area”; an area established to protect individuals from exposure to radiation/radioactive materials.

3.15 Screening Levels for Clearance (SLC): The radionuclide concentration or level of radioactivity corresponding to the disposition criterion allowing for

unrestricted release from radiological controls. Also referred to as the "Action Level (AL)" in this procedure.

3.16 Surficial Radioactive Material: Radioactive material distributed on any of the surfaces of a solid object. Surficial radioactive material may be either removable by non-destructive means (e.g., casual contact, wiping, brushing, washing) or fixed to the surface.

3.17 Upper Bound of the Gray Region (UBGR): The radionuclide concentration or level of radioactivity corresponding with the highest value in the range where the consequence of decision errors is relatively minor.

3.18 Upper Simultaneous Limit (USL): The upper boundary of the largest value in a data set.

4.0 Responsibilities

4.1 Radiation Safety Officer / Certified Health Physicist

Performs periodic assessment of procedure implementation as an element of periodic program reviews.

Provides technical interpretations of program requirements/guidance.

4.2 Project Health Physicist/Authorized User

Select appropriate measurement techniques and instrumentation based on radionuclides of concern, physical characteristics of M&E, levels of radioactivity inside the RCA, and other site conditions.

Determine when reference background area measurements are required and identify appropriate reference background areas.

Identify and approve SLCs.

Select final disposition option based on survey results.

Reviews and dispositions associated survey record

Direct corrective actions for any identified deficiencies during survey review.

Consult with the RSO/CHP when guidance is needed.

4.3 Radiation Safety Support Staff

Reviews the item proposed for release (sufficiently clean and dry to survey and prepares survey approach.

Consults with AU/RSO, as needed, to ensure the specific item's survey design is sufficient to address potential for residual radioactivity including inaccessible surfaces.

Conduct radiological surveys and document results.

Release M&E based on survey results and as directed by this procedure. For complex items, AU concurrence should be obtained prior to release.

5.0 Precautions, Limitations, and Prerequisites

5.1 Precautions

Unsealed radioactive materials can spread through direct contact or by airborne particulate resuspension & deposition on nearby surfaces. RSSS should consider potential pathways for cross-contamination when determining the scope of clearance surveys and where to perform biased measurements.

When internally deposited residual radioactivity is suspected (e.g., in pumps or motors), measurements of air intake plenums or intake filters serve as good confirmatory indicators of residual radioactivity potential.

Radon daughter products may build-up on surfaces with high air flow or on surfaces subject to static charge (e.g., hardhats). RSSS should consider potential for radon daughters (from natural sources) when initially evaluating unexpected positive results for both alpha and beta residual radioactivity and, perform and document recounts, as appropriate, to assess if the results are false positives. Regardless of radon daughter presence, SLC must be met prior to clearance.

Porous materials (e.g., wood, paper, cardboard) may contain volumetric radioactivity from infiltration or penetration and are more difficult to justify for unconditional release using this operating procedure. These types of materials should be excluded from entering the RCA when practicable; adequately covered to eliminate potential for contact with unsealed radioactive materials or considered waste.

5.2 Limitations

This procedure applies to fixed and removable contamination on accessible surfaces.

The selected survey instruments, counting parameters, and conditions should be capable producing a calculated MDC (as shown in OP-3407/3408) less than or equal to the SLC. Consider extending count times or moving to lower background areas when MDCs exceed the SLC in measurements that are below the critical level (Sc).

5.3 Prerequisites

Use caution to avoid contacting potentially energized components when conducting M&E surveys – watch for warning labels.

6.0 Equipment

None.

7.0 Instructions

7.1 Categorize the M&E as “impacted” or “non-impacted” – Non-impacted M&E are excluded from clearance survey requirements.

7.1.1 M&E (or portions) that did not enter an RCA and was not used in direct

contact with unsealed radioactive materials are non-impacted and excluded from clearance survey.

7.1.2 M&E (or portions) inside an RCA with no reasonable potential for residual radioactivity exceeding background may be considered non-impacted and excluded from clearance survey. The RSSS should consult with the AU/RSO as needed prior to release excluded items and document the exclusion decision with sufficient details to support decision.

7.1.3 M&E used in direct contact with unsealed radioactive materials or, used inside an RCA without documentation of a non-impacted categorization decision are impacted and require a survey.

7.2 Describe the M&E

7.2.1 Objects with less than 1,000 cm^2 (160 in^2) of impacted surface area are small objects. Objects with greater than 1,000 cm^2 of impacted surface area are large objects. Exact measurements are typically not necessary but, the surveyor should use conservatism in estimates.

7.2.2 Estimate the inherent value of the M&E. If disposal of the M&E requires fewer resources than performing a complex survey necessary to meet all requirements of this procedure, the surveyor may recommend disposition as waste without additional effort. As these situations arise, Project Management (PM, AU/RSO) for the temporary job site should be consulted to provide guidance on disposition options (i.e., complex survey versus waste disposition).

7.2.3 Identify radiations of interest (alpha, beta, gamma) based on radionuclides of potential concern listed in the project documents. If radionuclides of potential concern are not provided in project documents consult the AU/RSO for additional instructions. “Difficult-to-detect” radionuclides of concern (i.e., those that decay with maximum beta energy less than 0.15 MeV and radionuclides that decay by electron capture or isomeric transition) require further consultation with the RSO, or designated Project HP, to ensure they are accounted for in the survey methodology or determination of SLCs.

7.2.4 Notify the AU/RSO if there is a potential for volumetric contamination (porous surfaces) or a potential for contamination on difficult-to-access surfaces.

7.2.5 If necessary and practicable, disassemble the M&E to ensure all impacted surfaces are accessible for survey. Disassembly of complex M&E or components with stored energy potential shall be done by/under the direct observations of a subject-matter expert. Consult with the Site Safety & Health Officer or M&E Subject Matter Expert to ensure energy sources are adequately deenergized or protected from discharge prior to conducting surveys. Do not contact potentially energized systems!

7.2.6 Determine if contamination is uniformly distributed over impacted surfaces or if there is a reasonable potential for contamination to be

limited to small areas of elevated activity.

7.2.7 If necessary, segregate the M&E based on physical size, inherent value, radiations of interest, and distribution of contamination.

a. Communicate all potential issues to the PHP/AU prior to performing surveys.

7.3 Determine the Screening Levels for Clearance

7.3.1 New York / NRC Jurisdiction: For decommissioning-related activities under NYS/NRC jurisdiction, refer to the approved decommissioning plan. For other activities or when the DP does not provide screening levels for clearance of M&E, refer to the levels provided in the license activity-governing Radiation Safety Manual (e.g., OP-5010, Table 2).

7.3.2 DOE: For temporary job locations at sites controlled by DOE release limits for personal property SHALL be developed and approved prior to survey as described in DOE Order 458.1. Section 4.k(6)(f)1.b states the surface contamination limits from former DOE Order 5400.5 (MARSAME Appendix E, Table E.2) may be applied until replaced or revised as described in DOE Order 458.1. Cabrera will use MARSAME Appendix E, Table E.2 as SLC for release of M&E from DOE temporary job site activities unless alternative site/task-specific authorized release limits are specified in work control documents.

7.3.3 California Jurisdiction: For temporary job locations using Cabrera's CARML the SLC will be as defined in a regulator accepted work control document; absent a defined SLC, clearance will be based on a background threshold value (BTV) based on reference background conditions or baseline surface measurements collected prior to the M&E's use in a radiologically controlled/restricted areas. In these cases, the BTV will be calculated as: (a) the mean plus three standard deviations, (b) the critical value of the net count (as shown in OP-3407/3408) or (c) the 95% USL calculated using the "BTV Module" in EPA's ProUCL software.

7.3.4 Convert the selected SLC from dpm/100 cm^2 into counts per minute (cpm) using the following equation:

$$Net\ CPM = \frac{N_S}{t_S} - \frac{N_B}{t_B} = SLC \times \varepsilon_t \times \frac{A}{100\ cm^2}$$

Where:

N_S = Sample Counts

N_B = Average Background Counts

t_S = Sample Count Time (minutes)

t_B = Background Count Time (minutes)

SLC = Screening Level Criteria (dpm/100 cm^2)

ε_t = Total Efficiency (see OP-3402)

A = Probe Active Area (cm^2)

The SLC may be converted to total counts (as observed on the typical instrument) by adding the net cpm value to the average background cpm value, and then multiplying by the sample count time (t_S).

7.4 Selection of Appropriate Detector, Meter, and Count Time.

Consult with the PHP/AU/RSO for guidance, as needed. The MDC should be determined to ensure SLCs are achievable using the planned combination of equipment selected, actual background conditions, and count time settings; consult with the PHP/AU/RSO for guidance, as needed to ensure MDCs are within established data quality objectives.

7.4.1 Calculate the MDC as described in OP-3407/3408 based on the selected instrument.

7.4.2 Estimates of background counts should represent ambient background at the location where the clearance surveys are performed at the time they are being conducted.

- The background count time (t_B) for all clearance surveys shall be equal to or longer than the sample/measurement count time (t_S); both count times shall be at least one minute.
- The background count time (t_B) for surveys of large items should be 10x the sample/measurement count time (t_S) to ensure adequate precision in the average background level.

7.4.3 Note that swipe counting may be conducted in any area provided the background is as low as reasonably achievable and reasonably stable.

7.4.4 Estimates of total efficiency should be obtained using OP-3402, *Calculating Alpha and Beta Total Efficiency for Field Instruments*.

7.4.5 Adjust the sample count time and background count time, if necessary, to ensure the MDC is less than or equal to the SLC.

7.5 Survey Small Objects with Fixed and Removable Surface Activity

7.5.1 Position detector so it covers as much of the accessible surface as practicable.

7.5.2 Collect data as described in OP-3407, *Operation of Contamination Survey Meters* using the count time for total activity selected in Step 7.4.

7.5.3 Record the survey results and surveyor details in an RSO-approved form/log.

7.5.4 Perform sufficient measurements of total activity to cover 100% of the accessible surface.

7.5.5 Use a disc smear (typically two-inch diameter) to collect a removable activity sample at each location a total activity measurement was performed. OP-3102, *Wipe Sampling Procedure* describes the proper method for collecting removable activity samples including special

circumstances. Swabs may be used for areas too small to swipe with a disc smear. Swab use should be noted on the survey from when used. Cloth disc smears are typically used unless analysis will be by liquid scintillation counting or digestion radiochemistry were alternate media (e.g., wet paper smears) prescribed by the AU/RSO/work control document are used.

7.5.6 Count each smear using an appropriate sample counter as described in OP-3408, *Alpha-Beta Counting Instrumentation*. For most applications, gas-flow proportional or scintillation counting is adequate. Use the count time for removable activity determined in Step 7.4.

7.5.7 Record the alpha and beta smear counts as described in the approved work/decommissioning plan, on a survey form (OP-3601, *Radiological Surveys* provides an example survey form), or in a field logbook. ALL M&E CLEARANCE SURVEY ACTIVITIES MUST BE DOCUMENTED!

7.6 Determine Minimum Number of Measurement Locations for Large Objects

7.6.1 For the purposes of clearance surveys and conservatism in the process, The Null Hypothesis is that "the M&E contains residual surface radioactivity that exceeds the SLC.

7.6.2 The Type I and Type II decision error rates are set equal to 0.05 to be consistent with the acceptable decision error rates used to calculate the MDC values in MARSAME. If stakeholders prescribe alternate error rate values, consult with the PHP/RSO for guidance.

7.6.3 The relative shift can be estimated using the following equation, assuming Poisson counting statistics:

$$Relative\ Shift = \frac{\Delta}{\sigma} = \frac{SLC\ (net\ cpm\ from\ Step\ 7.3.4)}{\sqrt{N_S}/t_S}$$

Where:

Δ = width of gray region (SLC – Bkgd, cpm)

σ = standard deviation of sample counts equal to the SLC, equal to the AL in units of total counts from Step 7.3.4.

7.6.4 Use Table A.2b in MARSAME Appendix A to look up the minimum number of survey unit measurements that correspond to the next lowest relative shift value below the calculated relative shift.

- If the relative shift is between 1 and 3 use the following table to

determine the minimum number of survey unit measurements.

Number of Survey Unit Measurements ($\alpha = \beta = 0.05$)

Relative Shift	Number of Msmnts	Relative Shift	Number of Msmnts	Relative Shift	Number of Msmnts
1.0	32	1.5	18	2.0	13
1.1	28	1.6	16	2.25	11
1.2	24	1.7	15	2.5	11
1.3	22	1.8	14	2.75	10
1.4	19	1.9	13	3.0	10

- If the calculated relative shift is any value greater than 3, use 3 to ensure a minimum of 10 survey unit measurements.
- If the calculated value is any value less than 1, consult with the PHP/RSO for guidance.

7.7 Survey Large Objects with Fixed and Removable Surface Activity

7.7.1 Identify systematic or random locations representing the accessible surface of the object being evaluated for unconditional release. Use the minimum number of locations identified in Step 7.6.

7.7.2 Identify bias locations based on professional judgement to investigate all locations where residual radioactivity would likely be present based on the use of the object and the radioactivity at the site.

7.7.3 Collect data as described in OP-3407, *Operation of Contamination Survey Meters* using the count time for total activity determined in Step 7.4.

7.7.4 Record the alpha and beta counts as described in the approved work/decommissioning plan, on a survey form (OP-3601, *Radiological Surveys* provides an example survey form), or in a field logbook.

7.7.5 Use a disc smear to collect a removable activity sample at each location a total activity measurement was performed. OP-3102, *Wipe Sampling Procedure* describes the proper method for collecting removable activity samples.

7.7.6 Record the alpha and beta smear counts as described in the approved work/decommissioning plan, on a survey form (OP-3601, *Radiological Surveys* provides an example survey form), or in a field logbook.

7.8 Evaluate Survey Results

7.8.1 Compare results against applicable SLCs. Limited recounting of

measurement locations or smears may be conducted for those results nearest to an SLC to verify results do not exceed an SLC.

7.8.2 The item may be released when all results are verified below SLCs and any requested/required AU/PHP/RSO concurrence is obtained. The surveyor should complete the survey documentation and obtain concurrence for complex items prior to release.

7.8.3 If any final result exceeds an SLC, the item remains impacted by residual surface radioactivity requiring controls until adequate decontamination and additional survey prior to clearance.

7.9 Disposition Options for M&E with Surface Radioactive Material Exceeding SLCs

7.9.1 Small inexpensive objects may be identified as investigation derived waste and disposed of in accordance with a project-specific waste management plan.

7.9.2 Objects with higher intrinsic value may be decontaminated as described in OP-3805, *Decontamination of Radioactivity from Equipment and Tools* and resurveyed using this SOP.

7.9.3 Objects with high intrinsic value (e.g., heavy equipment) may have:

a. A separate unconditional release survey plan prepared for that piece of equipment

b. A dose assessment performed to demonstrate compliance with 10 CFR § 20.1301, 10 NYCRR § 16.7, 12 NYCRR § 38.19, or 17 CCR § 30253, which is inclusive of 10 CFR § 20.1301. For DOE sites a dose assessment may be performed as described in DOE Order 458.1.

c. Continued use with radiological controls maintained.

8.0 References

- 10 CFR § 20.1301, *Dose Limits for Individual Members of the Public*
- 10 CFR § 20.1501, *General, Requirements for Surveying and Monitoring*
- 10 CFR § 20.2103, *Records of Surveys*
- 10 NYCRR § 16.7, *Radiation Dose Limits for Individual Members for the Public*
- 10 NYCRR § 16.10, *Inspections, Surveys, Checks and Tests; Vacating Installations; Securing Radiation Sources*
- 10 NYCRR § 16.17, *Records*
- 12 NYCRR § 38.19, *Radiation Dose Limits for Individual Members of the Public*
- 12 NYCRR § 38.22, *Surveys, Checks, and Tests*
- 12 NYCRR § 38.28, *Records*
- 17 CCR § 30253, *Standards for Protection Against Radiation*
- DOE Order 458.1, *Radiation Protection of the Public and the Environment*

- NUREG-1575, Supp. 1, *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)*
- OP-3805, *Decontamination of Radioactivity from Equipment and Tools*
- OP-3401*, HP Instrument General Quality Control Procedure*
- OP-3402*, Calculating Alpha and Beta Total Efficiency for Field Instruments*
- OP-3601*, Radiological Surveys*
- OP-3407*, Operation of Contamination Survey Meters*
- OP-3408*, Alpha-Beta Counting Instrumentation*

9.0 Required Records

Survey records shall be maintained for three years unless project documents provide other instructions (10 CFR § 20.2103, 10 NYCRR § 16.17, 12 NYCRR § 38.28 or 17 CCR § 30253, which is inclusive of 10 CFR § 20.2103).

Survey records should include:

- o Diagram or photo of the object(s) released (to support release decisions for large complex surveys) with specific locations where wipe tests were performed
- o List of M&E surveyed
- o Background radiation levels with appropriate units
- o Survey results with appropriate units with all results exceeding the SLC identified
- o Make and model number of instruments with calibration date details
- o Surveyor name, survey date
- o Other details, as directed by work control document or the RSO.

10.0 Attachments

None.

CABRERA SERVICES
RADIOLOGICAL • ENGINEERING • REMEDIATION

OPERATING PROCEDURE

FOR

VOLUMETRIC AND MATERIAL SAMPLING WITHIN RADIOLOGICAL CONTROL AREAS

OP-005

REVISION 2.0

Reviewed by:

David Wunsch, Quality Assurance Manager — 4/12/13 Date

Approved by:

Henry Siegrist, CHP, PE, Radiation Safety Officer — 4/12/2013 Date

1.0 PURPOSE

This procedure provides the methods Cabrera Services Inc. (CABRERA) personnel will utilize to collect volumetric and material samples for radiological analysis. Adherence to this procedure will provide assurance that personnel exposures will be As Low As Reasonably Achievable (ALARA), personnel will remain free of contamination, and contamination will not be spread beyond the designated contaminated area.

2.0 APPLICABILITY

This procedure is applicable to all volumetric and material samples collected by CABRERA personnel to fulfill sampling requirements.

3.0 DEFINITIONS

3.1 Geiger-Mueller (G-M) Counter – A radiation detection and measuring instrument. It is sometimes called a G-M counter, or Geiger counter, and is the most commonly used portable radiation instrument. It consists of a gas-filled tube containing electrodes between which there is an electrical voltage but no current flowing. When ionizing radiation passes through the tube, a short, intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses/second measures the intensity of the radiation field.

3.2 Global Positioning System (GPS) – A satellite-based global navigation system that consists of: a collection of 24 satellites in orbit above the Earth; several in-orbit spares; and a ground-based control segment. The satellites transmit signals that are used for three-dimensional (latitude, longitude, and elevation) global navigation. A GPS-derived position determination is based on the arrival times, at an appropriate receiver, of precisely timed signals from the satellites above the user's radio horizon.

3.3 Impacted Area – According to MARSSIM, impacted areas have a potential for radioactive contamination (1) based on historical data or (2) they contain radioactive contamination based on past or preliminary radiological surveillance. This includes areas where radioactive materials were used and stored; records of spills, discharges, or other unusual occurrences resulted in the spread of contamination; and, areas where radioactive materials were buried or disposed. Areas immediately surrounding or adjacent to these locations are included in this classification due to the potential for inadvertent spread of contamination.

3.4 Ionizing Radiation – Radiation that has sufficient energy to remove electrons from atoms which produces ions. Examples include alpha, beta, gamma, and X-rays.

3.5 Minimum Detectable Concentration (MDC) – The net concentration that has a specified chance of being detected; it is an estimate of the detection capability of a measuring protocol and is calculated before measurements are taken. For purposes of this procedure, MDC for removable radioactive contamination is defined as the smallest amount of sample activity that will yield a net count, with a 95% confidence level, based upon the background count rate of the counting instrument used.

3.6 Sediment – According to MARSSIM, sediment includes soil and other solid material that has settled to the bottom of a liquid (e.g., water).

3.7 Site Safety and Health Plan (SSHP) – The SSHP provides evacuation routes for the site and its immediate area, as well as the names and telephone numbers of common emergency contact personnel for the worksite.

3.8 Subsurface Soil – According to MARSSIM, subsurface soil includes any soil not considered surface soil. It is typically anything greater than 15 centimeters (6 inches) below the ground surface.

3.9 Surface Soil – According to MARSSIM, surface soil includes the top layer of soil that is available for direct exposure, growing plants, re-suspension of particles for inhalation, and mixing from human disturbances. According to Title 40 of the Code of Federal Regulations, Part 192 (40 CFR 192), this layer is represented as the top 15 centimeters (6 inches) of soil.

3.10 Volumetric Sample – A sample of material taken to determine the radioactivity content in units of activity per unit volume or mass. It does **NOT** apply to loose surface material sampled using a cloth smear/wipe or to activity present only on the surface of solid materials.

3.11 Water Sample – A sample of surface water, groundwater, drinking water, or other hydrological system sampled to determine radioactivity content in units of activity per unit volume or unit mass.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

4.1.1 Special situations will be evaluated and incorporated in site-specific work plans (e.g., evaluating trends for airborne deposition, determining contamination profiles via down-hole measurements, measuring non-radiological contaminants, etc.).

4.1.2 Personnel will not exceed the load ratings stamped on shipping containers to prevent container degradation during shipment. Prior to shipment, personnel will consult with the analytical laboratory for

approved packaging materials and shipping methods. Deviations from approved work plans will be brought to the attention of the Site Radiation Safety Lead.

4.1.3 Personnel will utilize a field-sampling logbook to document sampling information.

4.1.4 Samples that require alpha or beta spectroscopy or isotopic discrimination will be sent to an approved laboratory for analysis. If onsite gamma spectroscopy is utilized, quality control (QC) samples may be sent to an approved laboratory for analysis, in accordance with the approved site-specific work plan.

4.1.5 Individuals collecting volumetric and material samples will be familiar with the requirements set forth in the current, approved version of this procedure.

4.1.6 Personnel will decontaminate radiologically contaminated sampling equipment in accordance with *Decontamination of Equipment and Tools* (OP-018). Equipment that is contaminated with non-radiological waste will adhere to decontamination techniques discussed in *Field Equipment Decontamination* (OP-373).

4.2 Limitations

4.2.1 Sample media containing radiological contamination may also contain non-radiological contamination that will not affect the radiological components of a sample. Therefore, personnel will follow the stricter guidelines associated with non-radiological contamination, if present. If only radiological contamination is present, it is unnecessary to adhere to guidelines governing non-radiological contamination.

4.2.2 It may be necessary to place samples on ice should a non-radiological component be present. Most radiological samples are unaffected by and therefore ***do not*** need to be placed on ice. It is unnecessary for personnel to collect separate samples for radiological and non-radiological components.

Note: Samples containing tritium (^{3}H) or carbon-14 (^{14}C) contamination may convert to gaseous components resulting in sample loss from biological activity. Ice will always be used to preserve this type of radiological contamination. An exception is airborne ^{3}H sampling utilizing distilled water and bubbler collection equipment.

4.3 Requirements

4.3.1 Instrumentation used in surveys will be checked with standards daily and verified to have current valid calibration.

4.3.2 Personnel will perform direct surface radiation measurements prior to sampling at each location. They may identify gross contamination, which could require samples and sampling equipment to be treated as radioactive for transport purposes.

4.3.3 Personnel will utilize the following documentation when performing volumetric and material sampling:

- Record forms
- Sample chain-of-custody (COC) forms
- Field-sampling logbook

4.3.4 Records will be maintained in accordance with *Records Management* (OP-187).

5.0 EQUIPMENT

5.1 The following is a list of the minimum equipment required to perform field volumetric sampling under this procedure:

- A Lietz level log book 8152-50 or the equivalent
- Survey form(s)
- Chain-of-Custody forms
- Sample containers
- Indelible ink marker
- Tap water
- Clean paper towels
- Brushes for decontamination, as needed
- Sample location markers
- Digging implement: garden trowel, shovel, spoons, post-hole digger, etc.
- Applicable sampling equipment
- Re-sealable plastic bags (approximately one-gallon capacity)
- Twist-ties
- Masking or duct tape

5.2 In addition to the above list, water sample collection may also require the following:

- Instrumentation to make water quality measurements that include: dissolved oxygen, pH, temperature, conductivity, and oxidation-reduction potential. This data may assist in the interpretation of analytical data and

the selection of sampling sites.

- Preservative(s), per analytical laboratory recommendations.

5.3 The following is a list of the minimum required equipment to perform sample packing and shipping under this procedure:

- Ludlum model 3 rate-meter with Ludlum model 44-9 G-M detection probe or equivalent
- Smears for removable activity and Ludlum 2929 smear counter or equivalent
- Micro Rem Ion chamber dose rate instrument or equivalent
- Boxes, coolers, or similar shipping containers for samples
- Clear packing tape
- Zipper-locking plastic bags
- Packaging material (e.g., plastic, vermiculite, preformed poly-foam liner, or equivalent)
- “Fragile” and “This Side Up” self-adhesive labels
- Mailing labels

5.4 The following is a list of sampling equipment that may be used for specific types of materials:

- Drains or pipes: plumber’s snake, swabs
- Residues: trowels, scoops
- Concrete or asphalt: core boxes, hammer, and chisel
- Metals: emery cloth or scraping tool
- Dusts: scraping tool and plastic bags

6.0 RESPONSIBILITIES

6.1 Corporate Radiation Safety Officer (RSO) – Will monitor compliance and ensure that personnel who collect volumetric and/or material samples are qualified by training and experience to perform this procedure.

6.2 Radiation Protection Technicians (RPT) – When collecting volumetric and/or material samples, are responsible for knowing and complying with this procedure.

6.3 Project Manager (PM) - Responsible for the radiological safety of all personnel on site, ensuring that if they collect volumetric and/or material samples, that

they are adequately trained, understand this procedure, and have access to a copy of procedures for reference.

6.4 Sample Collectors - Personnel who collect volumetric and material samples and are responsible for understanding and complying with this procedure.

6.5 Site Radiation Safety Lead (SRSL) – Acts as the RSO's duly authorized representative for radiological issues when the RSO and their duly authorized representative are not onsite. The SRSL will be onsite when work is in progress, will perform the requirements established in this procedure, and ensure that they are implemented during field assignments. The SRSL has the responsibility to stop work if: any unsafe condition exists in the work area, non-compliance with procedural requirements occurs, or if significant changes in radiological conditions occur.

7.0 PROCEDURE

7.1 General Volumetric and Material Sample Collection

This section is applicable to the collection of all volumetric and material samples.

7.1.1 Outside sample locations will be identified and documented with GPS data and survey maps, where practical. Survey maps will be used to document survey results related to the samples (e.g., loose surface activity of sample container or sampling equipment).

7.1.2 Personnel will use survey maps to clearly illustrate sample locations inside buildings.

7.1.3 Personnel will delineate sampling locations that need to be relocated with an appropriate marker (e.g., stake, pin flag, spray paint, etc.) and label them with a unique number.

7.1.4 Prior to collecting a sample, personnel will ensure that they have the correct container type and size by contacting the analytical laboratory for sample size requirements based on the desired detection sensitivity.

7.1.5 Personnel will adhere to the following techniques when collecting volumetric and material samples:

- Perform loose surface activity surveys on sampling equipment that contacts sampling media to ensure no removable contamination exists. Document the results on the appropriate survey form.
- Samples that can fit into a $^{1}/_{8}$-inch by 2-inch planchette, and require gross alpha and/or beta/gamma results, may be counted in a Ludlum 2929 smear counter or equivalent. Ensure that minimum counting system sensitivity requirements are met by calculating MDC values for alpha and beta, as applicable.

- Place the sample into a planchette with the surface to be measured facing up.
- Count the sample for the appropriate length of time to meet MDC values described by work plans or other documents.
- Record count and counting time data, and calculate activity estimates on the appropriate survey form.
- If the collected sample is suspected to contain radioactivity above background levels, then survey sampling equipment for loose surface activity prior to collecting additional samples with the same equipment. Document the results on the appropriate survey form.
- Decontaminate sample equipment as necessary.

7.2 Surface and Subsurface Soil Sample Collection

Personnel will refer to *Surface Soil Sampling* and *Subsurface Soil Sampling* (OP-351 and OP-352, respectively) for more detailed techniques, as well as adhering to both Section 7.1 of this procedure and the following steps when sampling surface and subsurface soil:

7.2.1 Collect surface and subsurface soil samples by utilizing appropriate sampling equipment as detailed site work plans(e.g., spade, shovel, spatula, scoop, plastic or stainless steel spoons or split spoons, trowel, bucket auger, post-hole auger, etc.).

7.2.2 Carefully remove the soil layer correlating to the desired sample depth.

7.2.3 Place sample into the appropriate container and mix thoroughly to obtain a homogenous sample representative of the sampling interval. Remove large rocks, vegetation, and foreign objects which may be collected as separate samples. **Note:** It may be necessary to use a sieve or screen to remove them.

7.2.4 Fill sample container(s) to the top with sampling media.

7.3 Surface Water and Sediment Sample Collection

Personnel will refer to *Surface Water and Sediment Sampling* (OP-349) for more detailed techniques, as well as adhering to both Section 7.1 of this procedure and the following when sampling sediment and surface water:

7.3.1 Collect sediment and surface water samples by utilizing appropriate sampling equipment. When collecting sediment samples, personnel may utilize the following: spade, shovel, spatula, scoop, trowel, bucket auger, tube auger, sediment coring device, Ponar or Ekman dredge,

etc. When collecting surface water samples, personnel may utilize the following: ladle, scoop, pond sampler, funnel, etc.

Note: It is important to minimize disturbance of the sediment caused by sampling activities. Move slowly and approach sampling location(s) downstream for moving water and downwind for stationary water.

7.3.2 Continue with one the following steps depending on whether sediment or surface water is being collected:

- **Sediment**: Remove desired sediment thickness and volume slowly and gently from water using appropriate sampling equipment. Place sediment sample into appropriate container and mix thoroughly to obtain a homogenous sample representative for sampling interval. Decant surface water from sample or homogenization container prior to sealing or transfer. Use care to retain the fine sediment fraction during this procedure. Remove large rocks, vegetation, and foreign objects, all of which may be collected as separate samples. (**Note:** It may be necessary to use a sieve or screen to remove them.) Fill sample container(s) to the top with sediment.

- **Surface Water**: If surface water is deep enough, then it may be collected by dipping the sample container directly into the water. Fill sample container(s) to the top with surface water gently and slowly. While multi-parameter water quality measurements (i.e., dissolved O_2, pH, temperature, conductivity, oxidation-reduction potential, etc.) are not required for radiological analysis, they may assist in analytical data interpretation if non-radiological contaminants are present onsite. The PM will determine the necessity of these measurements.

7.4 Groundwater Sample Collection

Personnel will refer to “Groundwater Sampling” (OP-350) for more detailed techniques, as well as adhering to both Section 7.1 of this procedure and the following, when sampling groundwater:

Note: Low-flow sampling is a comprehensive technique that is not discussed within this procedure. Low-flow groundwater sampling will be conducted in accordance with *Low-Flow Groundwater Sampling Procedures* (OP-355).

7.4.1 Collect groundwater samples by utilizing appropriate sampling equipment (e.g., bailer, submersible pump, non-contact gas bladder pump, inertia pump, suction pump, etc.).

Note: It highly suggested to use dedicated sampling equipment (e.g., bailers) at each sampling location or well to prevent cross-contamination.

Note: It is important to minimize disturbance of the sediment caused by sampling activities. Lower all sampling equipment into the water column as slowly as practical, and ***do not*** allow the equipment to free-fall within the well.

7.4.2 When purging with a pump (not a bailer), the pump will be set at the screened interval. The sample will also be collected from the depth at which the pump was set.

7.4.3 All monitoring wells will be pumped prior to sampling. Purge water will be containerized onsite or handled as specified in the site work plan. Evacuation of a minimum of one (preferably three to five) volume(s) of water in the well casing is recommended for a representative sample. In a high-yielding groundwater formation that has no stagnant water above the screened section of the well, evacuation prior to sample withdrawal is not critical. Evacuation is, however, recommended when monitoring data will be used for enforcement actions.

7.4.4 Fill sample container(s) to top with water.

7.4.5 If non-radiological contaminants (i.e., metals) are present that require an acidified sample, then test the pH of the water sample. If the pH is greater than 2.0, add acid to reduce the pH to 2.0 or less. This should align it with the analytical laboratory protocols.

7.5 Material Sampling

Personnel will adhere to both Section 7.1 of this procedure and the following techniques when conducting material sampling:

7.5.1 Determine sample collection using sample media characteristics. Care will be taken to limit the potential for spreading contamination during sample collection. Determine sample quantities using the following criteria:

- Type of analyses required;
- Number of analyses requested;
- Detection sensitivity required of analytical result; and
- Estimated activity level of material.

7.5.2 Remove the material to be sampled by using the tools required and contamination control techniques to prevent loss of material from the sampled area.

7.6 Collection of Other Samples

7.6.1 For the purposes of this procedure, ‘other’ refers to any media type not previously defined in this document.

7.6.2 Prior to collecting the sample, consult with the analytical laboratory and SRSL for specific instructions on taking any ‘other’ sample types.

7.6.3 Removed foreign objects which are not representative of the desired sample matrix or which may affect the laboratory analysis.

7.7 Sample Packing and Shipping

7.7.1 The sample collector will use indelible ink in identifying sample media and location in assigning a unique number to the sample container label. Sample collectors are responsible for initiating the chain-of-custody form, in accordance with *Chain-of-Custody* (OP-008).

7.7.2 Personnel will adhere to the following techniques when labeling samples:

- Label container(s).
- Record sample identification, date, and time of sample collection on label.
- If sample containers contain water or are preserved with ice, then place clear plastic tape around the label.
- Wipe outside of sample container.

7.7.3 Personnel will adhere to the following techniques when preparing containers for shipment:

- Tape container openings such as box seams and cooler drains (when used) shut.
- Affix “This Side Up” labels on all four sides, and “Fragile” labels on a minimum of 2 sides of the container (e.g., box, cooler, etc.).
- Place mailing label with laboratory address on container(s).
- When shipping samples for analysis, line the shipping container(s) with plastic prior to placing samples inside. If shipping liquid samples, fill the bottom of the shipping container(s) with approximately 3 inches of an approved absorbent material (i.e., vermiculite, preformed poly-foam liner, etc.).
- It may be necessary to preserve non-radiological samples at temperatures not exceeding 4°C. If ice is required for preservation, then it will be packaged within two zipper locking bags and placed on and around sample containers.
- Arrange decontaminated sample containers in groups by sample

number.

- Arrange samples in shipping containers so that they do not touch and the potential for motion is minimized.
- Fill remaining spaces with absorbent material.
- Sign chain-of-custody form (or obtain signature) and indicate air bill number, if applicable. Seal the correct chain-of-custody copy in a zipper locking plastic bag and tape it to the inside of the shipping container top or lid.
- If a cooler serves as the shipping container, close the lid and secure latch. Tape the container shut on both ends, making several complete revolutions with packing tape.
- Use tamperproof seals provided by the analytical laboratory to securely seal shipping container and initial and date the seal.
- Conduct surface scan of shipping container. Record results on appropriate survey form and include a copy with the shipping label.
- Relinquish samples to the shipper and retain sample collection and shipment documentation for project file.

CAUTION: Shipments of samples containing potentially hazardous or radioactive materials may require specific packaging and shipping precautions not specified above. Consult the SRSL or analytical laboratory for instruction when shipping these samples.

Note: Do not exceed load rating for containers when shipping samples to prevent degradation of the container during shipping.

7.8 Sample Equipment Decontamination

Personnel will decontaminate sampling equipment to prevent cross-contamination between sample collections. The most common decontamination materials include: long-handled brushes, Masslinn cloth or similar wipes, tap water, paper towels, disposal container/bags.

Note: This procedure is not written in compliance with *Sampling Equipment Decontamination* (EPA SOP 2006). EPA's procedure pertains to the presence of chemical contamination, which may include volatile organic compounds. These can readily cross-contaminate sampling media. Radiological decontamination will therefore be in accordance with *Decontamination of Equipment and Tools* (OP-018).

7.9 Recordkeeping

7.9.1 Information will be documented clearly, neatly, accurately, and concisely, and prepared in dark, waterproof ink. Data will not be

obliterated by erasing, with whiteout, or by any other means. To make a correction, a single line will be struck through the error, and the corrector will initial and date the line.

7.9.2 The RPT, or designee, will review applicable forms for accuracy and completeness, and date and initial entries to validate the survey.

8.0 REFERENCES

- *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),* DoD, DOE, EPA and NRC, Revision 1 (2000).
- Radiation Safety Program, Cabrera Services Inc., Manual
- AP-005, *ALARA*, Cabrera Services Inc., Operating Procedure
- OP-008, *Chain-of-Custody*, Cabrera Services Inc., Operating Procedure
- OP-018, *Decontamination of Equipment and Tools*, Cabrera Services Inc., Operating Procedure
- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure
- OP-351,*Surface Soil Sampling*, Cabrera Services Inc., Operating Procedure
- OP-352, *Surface Soil Sampling*, Cabrera Services Inc., Operating Procedure
- OP-355, *Low-flow Groundwater Sampling Procedures*, Cabrera Services Inc., Operating Procedure

9.0 REQUIRED RECORDS

- Field-sampling logbooks
- Record forms
- Sample chain-of-custody (COC) forms
- Sample Status Log

10.0 ATTACHMENTS

There are no attachments associated with this procedure

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

RADIOLOGICAL SURVEYS

OP-001

Revision 3.0

Reviewed by:

David Wunsch, Quality Assurance Manager — 4/8/13 Date

Approved by:

Henry Siegrist, CHP, PE, Radiation Safety Officer — 4/8/13 Date

1.0 PURPOSE

The purpose of this procedure is to establish the framework and to define the requirements for Cabrera Services Inc., (CABRERA) personnel performing radiological surveys. Adherence to this procedure will provide reasonable assurance that the radiological surveys performed yeild reproducible results. In addition, adherence to this procedure will provide adequate control of radiation exposures As Low As Reasonably Achievable (ALARA).

2.0 APPLICABILITY

2.1 This procedure provides the requirements and general guidelines for identifying, scheduling, and performing routine, radiation, contamination, and airborne surveys by radiation safety personnel. Remediation and facility areas that are radiologically controlled (restricted areas) due to the potential for fixed or transferable contamination are considered for routine survey performance.

2.2 The following types of surveys may be performed using this procedure:

- Surveys for shipping radioactive materials (Department of Transportation [DOT] regulations may require additional consideration).
- Surveys performed to characterize facilities, sites, and/or release items potentially contaminated with radioactive materials from restricted areas.
- Surveys performed to provide information used to guide or direct decontamination and decommissioning of facilities and sites.

2.3 This procedure does not include survey requirements for radiation generating devices and survey requirements specified in radiation work permits (RWPs).

2.4 Approved work plans may require more or fewer surveys and controls to be applied at the site than described in this procedure.

3.0 DEFINITIONS

3.1 Radiological Control/Restricted Area – An area to which access is controlled to protect individuals against undue risks from exposure to radiation and radioactive materials.

3.2 Contamination Survey – A survey technique to determine fixed and removable radioactive contamination on components and facilities.

3.3 Radiation Survey – An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation.

3.4 As Low As Reasonably Achievable (ALARA) – An approach to radiation exposure control to maintain personnel exposures as far below the federal limits as the technical, economical and practical considerations permit.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

4.1.1 Instruments used to perform routine surveys should be operated in accordance with the respective operating procedures or manufacturer's recommendations.

4.1.2 Large area smears (LAS) may be used to augment (but not replace) the one hundred square centimeter (100 $cm^{2)}$ smear survey. LAS may be counted with a Ludlum Model 3 and 44-9 probe or Ludlum Model 2224-1 and 43-93 probe or equivalent. LAS are used to obtain immediate information concerning loose contamination for the purpose of radiological protection and to minimize time spent performing smears on an item easily identified as contaminated.

4.1.3 Personnel performing routine surveys must be logged in on a RWP in accordance with AP-012, *Radiation Work Permits* (if applicable).

4.1.4 Audible response instruments should be used during direct scan surveys.

4.1.5 The instruments used for routine surveys must be within current calibration and must have had a performance test check performed daily, or before use, in accordance with the instrument's operating procedure.

4.2 Limitations

4.2.1 The maximum probe speed during direct scan surveys of surfaces must be 3 centimeters per second (cm/sec).

4.2.2 The probe face must be held within ¼ inch of the surface being surveyed for alpha radiation, and within ½ inch of the surface being surveyed for beta-gamma radiation.

4.2.3 If an instrument used to perform routine surveys fails operational checks, it will be removed from service. Data collected during the period of instrument failure must be evaluated by the Radiation Safety Officer (RSO) or duly authorized representative.

4.2.4 Posting of radiological control areas must be performed in accordance with OP-019, *Radiological Posting*.

4.3 Requirements

4.3.1 Individuals performing surveys will obtain and review any previous surveys performed in the area, or on the object, to determine radiation conditions that may be encountered.

4.3.2 Only qualified individuals will perform surveys. Qualification will be determined on a case-by-case basis by the Project Manager, Radiation Safety Officer or their duly authorized representative. Qualification considers prior training, experience, and certifications such as Radiation Protection Technician or National Registry of Radiation Protection Technologists.

4.3.3 Survey samples must be analyzed in a low-background area, whenever practical, to ensure achieving the required sensitivity of measurements.

4.3.4 At a minimum, dose rate surveys must be performed in locations where workers are exposed to radiation levels that might result in: radiation doses in excess of 10% of the occupational dose limits – or – where an individual is working in a dose rate area of 2.0 millirem per hour (mrem/hr), or more.

4.3.5 Prevent access to unrestricted areas if contamination is found and immediately notify the RSO or duly authorized representative.

5.0 EQUIPMENT

5.1 Radiation and Contamination survey meters will be selected based on job specific requirements and be identified in the Site Work Plans.

5.2 Instruments used to perform routine surveys will be used in accordance with the applicable CABRERA administrative and operational procedures.

5.3 Authorized suppliers of properly calibrated and maintained equipment will supply/calibrate instruments; although equipment counting efficiencies may be determined by qualified CABRERA personnel.

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) - The PM is responsible for ensuring that personnel assigned the task of performing routine surveys are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

6.2 Radiation Safety Officer (RSO) - The RSO is responsible for monitoring compliance with this procedure and training personnel in performing radiation and contamination surveys. The RSO can also assist in the interpretation of the results obtained during surveys.

6.3 Site Radiation Safety Lead (SRSL) - During field assignments, the SRSL is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the SRSL will act as the RSO's duly authorized representative for radiological issues.

6.4 Radiation Protection Technicians (RPT) - The RPT performing radiation and contamination surveys are responsible for understanding and complying with this procedure.

7.0 PROCEDURE

7.1 Safety Considerations

The safety requirements specified in the job specific Health and Safety Plans (HASPs) and work plans, the Radiation Safety Program (RSP), and other safety documentation must be adhered to when performing surveys.

7.2 Initial Preparations

Obtain and review any previous surveys performed in the area to determine radiation conditions that may be encountered.

7.2.1 Obtain appropriate survey instruments and assure daily quality control (QC) checks have been performed prior to instrument use.

7.2.2 Obtain necessary forms, smears, and protective clothing, which will be used during the survey.

7.2.3 Plan any strategy for performing the survey before entering the area to reduce exposure time within the area.

7.2.4 If smearable contamination is expected to be above allowable limits, set up an entry/exit area which will prevent the spread of contamination.

7.3 Radiation Surveys

7.3.1 If radiation levels are unknown or previous surveys remain in question, first measure general area radiation levels using a Micro-R Meter or equivalent dose rate meter to determine if elevated radiation levels exist in the survey area.

7.3.2 Small Areas/Items/Containers – This survey technique is used to establish exposure rates from small areas, items, or containers that contain radioactive materials.

- Scan the entire surface area of the area, item, or container with a Micro-R or equivalent meter and record locations and readings on the Survey Form, in Attachment B, or an equivalent form.

- Measure the exposure rate at 30 centimeters from all surfaces or sides of the area, item, or container and record the location and readings on the Survey Form, in Attachment B, or an equivalent.
- Large waste containers used for shipment of bulk quantities of soil debris etc., may have a single dose rate measurement per accessible side of the container for ALARA purposes. DOT regulations may require additional dose rate measurements prior to shipping which is not covered by this procedure. Note readings on the Survey Form or an equivalent.

7.3.3 Facility Surveys – This survey technique may be used to release facilities (buildings, etc.) to "unrestricted" status or to determine the status of facilities requiring decontamination and decommissioning. Final release of a facility will be established using the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance.

- Establish a 1 meter by 1 meter grid system [or another work plan-approved grid] for the facility surfaces and use a marking system that assigns a unique number/letter to the center of each grid section. Graphically illustrate the location of the grid system on the Survey Form, in Attachment B, or an equivalent.
- Using a Micro-R Meter or equivalent obtain radiation levels at 1 meter from the grid center point and at contact with the grid center point. Record the reading on the Survey Form, in Attachment B, or an equivalent. If elevated readings are noted, scan the surface of the grid and note the location of any elevated readings with a marker on the form.
- Obtain Micro-R or equivalent readings from locations surrounding the facility, or within the facility, which do not contain activity. This establishes a background level for comparison to the reading taken above.

7.3.4 Area Surveys – This survey technique may be used to release land masses to "unrestricted" status or determine status of areas requiring decontamination before release. Final release of a site area will be established using MARSSIM guidance

- Establish a 10 meter by 10 meter grid system of the area to be surveyed [or another approved grid as provided by the work plan] using surveyor stakes or equivalent, which are numbered with a unique number/letter to identify the center of each grid. List the locations of the "gridded" system on the Survey Form or an equivalent.
- Using a Micro-R meter or equivalent, obtain radiation levels at 1 meter above the ground surface in the center of the grid. Record all readings on the Survey Form or an equivalent.

- Survey the remainder of the grid at the surface using an “S” pattern for the instrument. If elevated readings are noted above or below the grid center point reading, subdivide the grid into additional sub-grids and obtain readings at 1 meter above the ground surface. Record all readings on the Survey Form or an equivalent.

7.4 Contamination Surveys

7.4.1 If removable contamination is suspected or previous surveys are in question, first scan likely contaminated areas with an alpha (α) and/or beta (β) probe and determine if elevated areas of contamination exists. Obtain smear samples from any elevated areas and count smears in sample counter. If smearable contamination above limits set for the job is found, use appropriate protective clothing and entry control techniques to prevent the spread of contamination.

7.4.2 Small Areas/Items/Containers – This survey technique is used to establish total and transferable contamination levels on small areas, items, or containers, which contain radioactive materials.

- If the area, item, or container contains alpha activity, scan the area with an alpha probe at ¼ inch above the surface. Note total (fixed plus transferable) contamination readings on the Survey Form or an equivalent.
- If the area, item, or container contains beta activity, scan the area with a beta probe at approximately ½ inch above the surface to be surveyed and obtain reading following meter stabilization. Record meter reading on the Survey Form or an equivalent. The surface of a container can only be directly surveyed for beta activity if the radiation level from the container does not significantly elevate the beta probe background. Note total (fixed plus transferable) contamination readings on the Survey Form or an equivalent.
- Provide transferable smear contamination survey on the area, item or container by performing 100 cm^2 smears, at routine intervals, on the subject area, item, or container.
- Large waste containers used for shipment of bulk quantities of material will have one or more contact readings taken at routine intervals on the accessible sides of the container. Note total (fixed plus transferable) contamination readings on the Survey Form or an equivalent. **Note:** DOT regulations may require additional survey points.
- For large waste containers used for shipment of bulk quantities of material for disposal (or other large items such as soil moving equipment), determine the transferable surface contamination by taking LAS. Use Masslinn cloth or equivalent material to obtain a

LAS representative of the potentially contaminated area. Count the LAS, in a low background area, using alpha and beta detection equipment. If no transferable contamination above limits is found on the LAS, take several confirmatory 100 cm^2 smears at routine intervals on the object and count smears for alpha and beta activity. Record results on the Survey Form or an equivalent. **Note:** DOT regulations may require additional survey points.

Note: The presence of activity above transferable limits on a LAS signifies potential contamination. Determine actions to be taken with the RSO or SRSL.

7.4.3 Facility Surveys – This survey technique is used to aid in the release of facilities (buildings etc.) to "unrestricted" status or determine status of facilities requiring decontamination and decommissioning. Final release of a facility will be established using MARSSIM guidance.

- The grid system established in Section 7.3.3 will also be utilized for contamination surveys.
- Hold the beta probe at approximately ½ inch above the grid center point and obtain reading following meter stabilization. Record the meter reading on the Survey Form or an equivalent.
- If the readings are at background levels, randomly scan the remainder of the grid, concentrating on cracks, floor/wall joints, top of horizontal surfaces, ventilation ducts and grills, and other areas that might collect radioactive materials. Mark any locations above the release criteria on the Survey Form or an equivalent.
- If readings are at or near the release levels, scan grid surface and identify the portion of the grid that is above the release criteria. Note these areas on the survey form and mark the area of the grid with spray marker (or equivalent) on the Survey Form or an equivalent. Repeat steps 8.3.4 with an alpha probe at ¼ inch above the grid center point. If sufficient documentation of previous history is known about the facility and contamination is known not to be present, the alpha survey may not be required.
- One smear sample from a 100 cm^2 area will be taken in each grid. If the above survey found no elevated readings in the grid, the smear sample will be taken in the center of the grid. If elevated levels readings are identified the smear sample will be taken from the area where the highest reading was obtained.
- Each smear sample will be labeled with the grid location and counted for alpha and beta activity in the sample counter. The smear sample results will be recorded on the Survey Form or an equivalent.

7.4.4 Area Surveys – This survey technique is used to aid release of land masses to "unrestricted" status or determine status of area requiring decontamination before release. Final release of a facility will be established using MARSSIM guidance.

- The grid system established in Section 7.3.4 will be utilized for contamination surveys.
- Hold the beta probe at ½ inch above the grid center point and obtain reading following meter stabilization. Record the meter reading on the Survey Form or an equivalent.
- If readings are at background levels, randomly scan the remainder of the grid. Mark any locations above release criteria on the Survey Form or an equivalent.
- If readings are at or near the release levels scan the grid surface and identify portion of the grid that is above release criteria. Note these areas on the Survey Form or an equivalent.
- Areas contaminated with radioactive materials may require soil sample analysis to determine the activity concentration. The quantity and location of samples will be determined on a case-by-case basis.

7.5 Frequency and Requirements for Routine Surveys

Appropriate routine radiological surveys will be performed at the following frequencies as a minimum:

7.5.1 Radiation Surveys

- Upon initial entry after extended periods of closure,
- Daily, at contamination control points, where the potential exists for personnel to be exposed to dose rates greater than 2 mrem/hr,
- Daily, during continuous operation, and when levels are expected to change,
- Weekly, in routinely occupied areas adjacent to radiological control areas with dose rates greater than 2 mrem/hr,
- Weekly for operating High Efficiency Particulate Air (HEPA)-filtered ventilation units,
- Weekly, for any temporary Radiation Area boundaries to ensure that the Radiation Areas do not extend beyond posted boundaries, and
- Monthly, or upon entry if entries are less than monthly, for Radioactive Material Storage Areas.

7.5.2 Contamination Surveys

- Daily, at contamination control points from areas exhibiting contamination above surface contamination limits for the job site,
- Daily, in office spaces located in the radiological control areas,
- Weekly in lunchrooms or eating areas adjacent to radiological control areas,
- Weekly, in routinely occupied locker rooms or the shower areas adjacent to radiological control areas associated with site radiological work,
- Weekly, or upon entries, if entries are less frequent, in the areas where radioactive materials are handled or stored, and
- Weekly for all project offices on site.

7.5.3 Airborne Surveys

Airborne survey frequency, locations, and methods are determined by the RWPs and by the RSO/SRSL.

7.6 Identifying and Scheduling Routine Radiological Surveys

7.6.1 To assist in assuring surveys are scheduled, the RSO or duly authorized representative will identify and schedule routine surveys, as required by the radiological conditions and work activities.

7.6.2 Routine Survey Schedules or equivalent should be developed using a standard system for designating surveys such as:

Frequency of Survey	
• Daily	D
• Weekly	W
• Monthly	M
• Quarterly	Q
• Semi-Annually	S
• Annually	A
• Upon Entry	U

Type of Survey	
• Radiation	R
• Contamination	C
• Area TLD	T
• Air Sample	A

Example: DRC-1
Where:

D: is the survey frequency (Daily in this example)
R: is the type of survey (Radiation in this example)
C: is a type of survey (Contamination)
1 corresponds to the numerical sequence of the survey

7.6.3 Routine survey schedules should be submitted to, and reviewed by, the RSO or duly authorized representative.

7.6.4 Routine Survey Schedules should be indicated on form in Attachment A or an equivalent. Task Leaders may elect alternate methods of determining the information contained on the Routine Survey Schedule.

7.7 Using ALARA Principles for Scheduling and Performing Surveys

7.7.1 Routine surveys should not be performed in High Radiation Areas unless other work necessitates entry. Boundary verification surveys would be appropriate if an entry is not required.

7.7.2 Routine surveys should be performed in conjunction with other work surveys as much as practicable.

7.8 Performance of Routine Surveys

7.8.1 RPTs and qualified individuals will perform routine surveys in accordance with the applicable operational procedure.

7.8.2 Upon completion of a routine survey, the RPT will initial and date the appropriate Survey Form.

7.9 Periodic Evaluation of Routine Surveys

7.9.1 Routine Survey Schedules should be reviewed and updated periodically to ensure that all areas within the project boundaries are receiving the appropriate routine survey coverage.

7.9.2 Changes of conditions within the project area will be reported to the RSO or duly authorized representative and may require a modification of the routine radiological survey schedule.

7.10 Management Notification

The RSO should be notified, by the PM or duly authorized representative, of failure to complete a routine survey, as scheduled. The missed survey will be completed within 24 hours (or next working day) of discovering the inconsistency.

8.0 REFERENCES

- Title 10, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation, Subpart E,*Radiological Criteria for License Termination*
- Title 10, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation, Subpart F,*Surveys and Monitoring*
- Title 10, Code of Federal Regulations, Part 20.2103, *Records of Surveys*
- Radiation Safety Program, Cabrera Services Inc., Manual
- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure
- AP-010, *Personnel Protective Equipment Used Within Radiological Controlled Areas*, Cabrera Services Inc., Operating Procedure
- AP-012, *Radiation Work Permits*, Cabrera Services Inc., Operating Procedure
- OP-019, *Radiological Posting*, Cabrera Services Inc., Operating Procedure
- OP-020, *Operation of Contamination Survey Meters*, Cabrera Services Inc., Operating Procedure
- OP-021, *Alpha-Beta Counting Instrumentation*, Cabrera Services Inc., Operating Procedure
- OP-022, *Operation of Ionization Chambers* , Cabrera Services Inc., Operating Procedure
- OP-023, *Operation of Micro-R Meters*, Cabrera Services Inc., Operating Procedure

9.0 REQUIRED RECORDS

9.1 Survey records should include the following, at a minimum:

- A diagram of the area surveyed, if applicable.
- A list of items and equipment surveyed.
- Specific locations on the survey diagram where wipe test were taken.
- Background radiation levels with appropriate units.
- Contamination levels with appropriate units.
- Make, model number, and serial number of instruments used.
- Name of the person making the evaluation and recording the results and date.

9.2 Routine Survey Schedule

9.3 Survey Form

10.0 ATTACHMENTS

- Attachment A – Routine Survey Schedule
- Attachment B – Survey Form

Attachment A

Routine Survey Schedule

Routine Survey Schedule

Survey Designation	Location of Survey

Prepared By: _____ Date: _____

Reviewed By: _____ Date: _____

Attachment B

Survey Form

Survey Form

Location: Site:	RWP#	Survey #	Survey Type:	pg. 1 of __

Smear (CPM/100 cm^2) Direct Count (CPM/Direct Frisk)						circle one
No.	α	β	No.	α	β	
1			26			
2			27			
3			28			
4			29			
5			30			
6			31			
7			32			
8			33			
9			34			
10			35			
11			36			
12			37			
13			38			
14			39			
15			40			
16			41			
17			42			
18			43			
19			44			
20			45			
21			46			
22			47			
23			48			
24			49			
25			50			

Comments	Surveyed By:	Date:	Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	γ Bkg	Cal. Due		Key	
												■	A/S Location
												-	Boundary
												○	Smear
												□	Dose Rate _____ /hr
	Reviewed By:	Date:										*	Direct Reading CPM/direct frisk
												△	Grab Sample

OPERATING PROCEDURE

FOR

INTERNAL DOSIMETRY PROGRAM

OP-5205

(FORMERLY OP-002 & AP-007)

Revision 2.0
January 2021

Level of Use:
Information Use

APPROVALS	
President	*R. Flowers, PMP, CHMM*
Quality Assurance	*S. Liddy, CSP*
Health Physics	*M. Winters, CHP*
This procedure is the property of Cabrera Services Inc. and is considered approved and effective for the duration it is posted electronically to the Controlled Copy Document Repository.	

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History of Revisions		
Revision	**Month-Year**	**Description**
0	January 2000	AP-007, Bioassay Program. Initial issue. OP-002, Air Sampling & Analysis
1.0	April 2013	Substantial (major) revision of OP-002 to update overall program elements to latest regulations, guidance, and industry practices.
2.0	January 2021	Substantial (major) revision to update overall program elements to latest regulations, guidance, and industry practices. Incorporate all elements, including OP-002, Air Sampling & Analysis, into a single Internal Dosimetry Program procedure with accompanying title change. SMEs for this revision include B. Gaudette, M. Plonski, and D. Gills. Includes formatting and renumbering to OP-5205 per OP-2001. Title change to OP-5205, Internal Dosimetry.

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1.0 PURPOSE

The purpose of this procedure is to provide guidance on the establishment of radiological air monitoring and bioassay programs when required by a work controlling document or when observed/potential radiological conditions are likely to exceed posting criteria, public dose limits within Controlled/Restricted Areas, or a regulatory threshold for individual worker monitoring.

The measurement and sample data generated under this procedure, along with exposure duration information, is used by the Radiation Safety Officer (RSO) for determination and assignment of committed dose and committed effective dose to personnel that access radiologically Controlled/Restricted Areas, where appropriate.

Measurement data generated by this procedure is used by the RSO as the primary means to determine compliance with internal dose standards and individual internal dose monitoring thresholds.

2.0 SCOPE/APPLICABILITY

This procedure normally applies to all air sampling and bioassay analysis when conducted is support of licensed activities; when identified in a controlling work document or when directed by the RSO.

This procedure may be considered for use in Department of Energy (DOE) temporary job site applications when identified in the in the controlling work document (Radiation Protection Plan or Radiological Controls Manual). In these instances, the internal dosimetry related definitions, requirements, and criteria from 10 CFR 835 take precedence.

3.0 DEFINITIONS

3.1 Air Sample Survey – A survey technique which collects particulates from a known volume of air and determines the concentrations of radioactive materials associate with airborne particles.

3.2 Airborne Radioactivity Area – A room, enclosure, or area in which the radioactive material is dispersed in the form of dusts, fumes, mists, particulates, or vapors, and the concentration of the dispersed radioactive material is more than:

- The Derived Air Concentrations (DAC) specified in Table 1 Column 3 of Appendix B, 10 CFR § 20, or Agreement State Equivalent
- Concentrations such that an individual present in the area without respiratory protective equipment could exceed, during the hours the individual is present in a week, an intake of 0.6% of the Annual Limit on Intake, or 12 DAC-hours (10 CFR § 20.1003) or Agree State Equivalent.

3.3 Annual Limit on Intake (ALI) – The ALI of radioactive materials is the smaller amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year (40 hours per work week for 50 weeks) that

would result in a committed effective dose equivalent (CEDE) of 5 rem (0.05 Sievert [Sv]) or a committed dose equivalent (CDE) of 50 rem (0.5 Sv) to any individual organ or tissue.

3.4 Bioassay – A determination of kinds, quantities, or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body. A "baseline bioassay" is one that would be performed/collected from selected radiological workers prior to initial work in areas with radioactivity intake potential.

3.5 *Class* (or *lung class* or *inhalation class*) - A classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D (Days) of less than 10 days, for Class W (Weeks) from 10 to 100 days, and for Class Y Years) of greater than 100 days.

3.6 Committed Dose Equivalent (CDE or $H_{T,50}$) means the dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

3.7 Committed Effective Dose Equivalent (CEDE or $H_{E,50}$) – 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 ($H_{E,50} = \Sigma W_T H_{T,50}$).

3.8 Derived Air Concentration (DAC) - The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in Table 1, Column 3, of appendix B to §§ 20.1001-20.2401.

3.9 Derived Air Concentration-hour (DAC-hour) - The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the derived air concentration for each radionuclide) and the time of exposure to that radionuclide, in hours. A licensee may take 2,000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 5 rems (0.05 Sv).

3.10 Dose Equivalent (H_T) - 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).

3.11 Individual – Any human being.

3.12 Individual Monitoring — The assessment of dose equivalent by the use of devices designed to be worn by an individual; the assessment of committed effective dose equivalent by bioassay (see Bioassay) or by determination of

the time-weighted air concentrations to which an individual has been exposed, i.e., DAC-hours; or the assessment of dose equivalent by the use of survey data.

3.13 Individual Monitoring Devices (individual monitoring equipment) - means devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges, thermoluminescence dosimeters (TLDs), pocket ionization chambers, and personal ("lapel") air sampling devices.

3.14 Internal Dose - That portion of the dose equivalent received from radioactive material taken into the body.

3.15 Monitoring (radiation monitoring, radiation protection monitoring) - The measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.

3.16 Nonstochastic Effect - Health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect (also called a deterministic effect).

3.17 NRC Form 4 – The official record of previous exposure history which indicates deep dose, shallow dose, eye dose, the committed dose equivalent, the CEDE due to internally deposited radionuclides, and the total effective dose equivalent (TEDE).

3.18 Occupational Dose - The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released under 10 CFR 35.75, from voluntary participation in medical research programs, or as a member of the public.

3.19 Stochastic Effects - Health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

3.20 Survey - An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

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

3.22 Weighting factor W_T, for an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values of W_T are:

Organ Dose Weighting Factors	
Organ or Tissue	W_T
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone Surfaces	0.03
Remainder	[1]0.30
Whole Body	[2]1.00
[1] 0.30 results from 0.06 for each of 5 "remainder" organs (excluding the skin and the lens of the eye) that receive the highest doses.	
[2] For the purpose of weighting the external whole-body dose (for adding it to the internal dose), a single weighting factor, W_T=1.0, has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specific guidance is issued.	

3.23 Working **L**evel (WL) **-** 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 1.3x105 MeV of potential alpha particle energy.

3.24 Working Level Month (WLM) - An exposure to 1 working level for 170 hours (2,000 working hours per year/12 months per year=approximately 170 hours per month).

3.25 Year - means the period of time beginning in January used to determine compliance with the provisions of this part. The licensee may change the starting date of the year used to determine compliance by the licensee provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.

4.0 RESPONSIBILITIES

4.1 Radiation Safety Officer (RSO) – Monitoring compliance with this procedure and training of personnel in the use of the air sampling and bioassay analysis. RSO may assign training oversite responsibility to a Site Authorized User. The RSO can also assist in the interpretation of the results obtained during surveys and bioassay. The RSO serves as the senior authority on interpretation of internal dosimetry data (from bioassay and sampling results) and provides direction and guidance on means and methods, as needed.

4.2 Authorized User (AU) – During field assignments, the AU is the RSO's authorized representative for radiological issues when the RSO is not onsite and is responsible for ensuring that this procedure is properly implemented, and personnel are trained in the use of the air sampling and bioassay analysis.

4.3 Radiation Safety Support Staff (RSSS) – The RSSS performing air sampling and bioassay analysis is responsible for knowing, understanding, and complying with all provisions of this procedure. RSSS perform analyses and may direct initial corrective actions based on results. The RSSS is to notify the RSO of results above established As Low as Reasonably Achievable (ALARA) goals or limits for a given activity.

4.4 Other Personnel – Wear air samplers and provide bioassay samples, when requested by the RSO/AU/RSSS. Otherwise, air monitoring activities or bioassay analysis are typically performed only by appropriately trained/experienced RSSS members. With specific RSO concurrence and oversight of an RSSS member, other trained personnel may perform basic program support tasks (e.g., changing filter cassettes, verifying flow indicators, etc.)

5.0 PRECAUTIONS, LIMITATIONS, AND PREREQUISITES

5.1 Precautions

5.1.1 Air Sampling Precautions

Air samples run at altitudes more than 5,000 feet need to consider pressure adjustments for altitude and recorded flow-meter readings.

Avoid water contact with filter media due to potential for damage/corruption of the sample; use additional precautions when sampling under known/potential wet conditions.

Filter media are potentially contaminated. Use gloves, at a minimum when handling media. Use secondary containers (e.g., sleeves, envelopes, bags) when transporting used media/cassettes.

Air samplers may become internally contaminated during use, unrestricted release surveys of air samplers should include verification of clean internals by swiping of sampler inlet connections or other representative internal surfaces.

Air sampling lines should have the least number of bends and sharp turns in their construction, to preserve laminar flow within the air sampling line.

5.1.2 Bioassay Precautions

Bioassay analysis selection should be determined by radionuclide ingested.

Bioassay results may cause the generation of reports that should be copied for each worker involved. The reports should be maintained as a part of radiation exposure records for each individual.

5.2 Limitations

5.2.1 Air Sampling Limitations

Air samplers should only be operated in temperatures between –4 °F to 122 °F. RSSS personnel overseeing air sampling activities should consult with the RSO for guidance if operations outside this temperature range are anticipated or observed.

Particulate samplers and gross counting systems are ineffective at collection and measurement of certain radionuclides based on physical state or type and energy of primary decay emissions. Consult with the Senior RSSS or RSO for guidance on proper means to collect, measure, or otherwise account for difficult-to-detect radionuclides.

5.2.2 Bioassay Limitations

Frequency of bioassay:

- New hires if determination is made that previous intake occurred at a previous employer.
- Annually, if long project site deployment and concern of intake is present.
- Randomly, if RSO deems necessary.
- Suspected intake, if an airborne event occurred, or wounded personnel in a contaminated area.
- Termination, if determination is made that a potential intake exposure occurred.

5.3 Requirements

5.3.1 Air Sampling Requirements

Air sampling is required:

- To evaluate airborne hazards whenever respiratory equipment is used to limit intakes.
- To determine if the respiratory equipment provides adequate protection.
- When worker intakes are likely to exceed 0.1 ALI or 40 or more DAC-hours in a year.

- Shall be performed to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of radioactive material.

At a minimum, air flow rate meters (i.e., continuous air monitors, air samplers, and flow measurement devices) require annual calibration (once every 365 days) or, after repairs/modifications or, when damage is suspected.

The alpha (α) and beta (ß) counter used to count air samples will be calibrated (annually at a minimum), set-up before first use, and response checked prior to each daily use in accordance with OP-3401, *HP Instrument General Quality Control Procedure.*

The RSO or authorized representative will review any applicable completed forms for accuracy and completeness.

5.3.2 Bioassay Requirements

Bioassay is required:

- To evaluate airborne hazards when respiratory equipment is used to limit intakes.
- To determine if the respiratory equipment provides adequate protection.
- When worker intakes are likely to exceed 0.1 ALI or 40 or more DAC-hours in a year.

The alpha (α) and beta (ß) instrumentation used to count bioassay smears will be calibrated, set-up, and response checked prior to each daily use in accordance with OP 3401, *HP Instrument General Quality Control Procedure*.

6.0 EQUIPMENT

6.1 Low volume area sampler: “Low-Vol”; F&J Model LV-1 or equivalent rotary vane style pump (typical flowrate and readout in units of liters per minute).

6.2 High volume area sampler: “Hi-Vol” (typical flowrate and readout in units of cubic feet per minute or cubic meters per minute); one example is a Hi-Q Model HVP-4300 AFC.

6.3 Breathing Zone (BZ) samplers: Any sampler that collects data from the worker’s breathing zone; typically, a waist-worn battery-powered sampler pump and lapel sample head connected by a short length of Tygon tube with flow rates measured in liters per minute.

6.4 Suitable scintillation/gas-flow proportional counter

6.5 Suitable portable survey instrument

6.6 Required equipment designated by testing medical/laboratory facility

7.0 INSTRUCTIONS/PROCEDURE

7.1 Air Sampler Flow/Flow Meter Calibration

Perform or verify that the required calibration (flow rate indicator/totalizer) has been performed per instrument specific procedure or operating manual. Flow rate indicators must be calibrated at least annually and meet an overall measurement uncertainty less than 20%.

7.2 Air Sampling Set-up and Collection

7.2.1 Select the type of air sampler to be used and verify that the instrument has a currently valid calibration (within one year). If the work area contains radioiodine, tritium, or other isotopes that require special sampling, contact the RSO for guidance before proceeding.

7.2.2 Attach the air sampling head to the intake of the volume sample pump or to the Tygon tubing of the lapel sampler; lengths of tubing may be used to extend the distance between the sampler and the sampling head provided pre-operational flow verification/calibration is performed in the same configuration. Tubing material should have minimal bends and should be made of material that limits static effects. Samplers should consult with RSO for guidance when sampling for lengths more than 10 feet.

7.2.3 Obtain the filter paper, to be used in the sample, and mark the back side of the filter with a unique number or mark, to represent the clean side of the filter. During the collection and handling of air sample filter papers, caution must be used to prevent the samples from being cross contaminated by radioactive materials.

7.2.4 Place the filter paper in the holder and position the sampler, as indicated below.

- Area air samples are collected by placing the sample head at 3 to 6 feet above the floor and as close to the work area, as practical. If there is airflow in the work area, the sampler should be placed “downwind” of the area where there is the greatest potential for radioactive material to be suspended in air.
- BZ/lapel air samples are collected from the workers breathing zone. The sample head is attached to the shoulder of the worker with the sample head facing forward. The sample head will be no further than 12” from the breathing zone. The Tygon tubing connecting the sample head to the pump is run down the back of the worker with the sample pump attached to the worker’s belt.

7.2.5 When the filtered sample head is in position, start the low volume or high-volume sample pump and adjust the flow rate to a stable value that maximizes the volume of air collected relative to other considerations (i.e., filter damage, battery life, turbulence at the filter face); consult with the Senior onsite RSSS member or RSO for guidance on most

appropriate sampling locations, equipment, and flow rates to meet data quality objectives.

7.2.6 Record the time the sample was started and the initial flow rate of the sample pump on Attachment A, Air Sample Data Sheet. Approved electronic templates may be used in place of this form as long as the equivalent information is provided, as described in this procedure.

7.2.7 If possible, identify the radionuclides, which will be encountered in the work area and record the radionuclides along with the DAC for each radionuclide in the space provided on the Air Sample Data Sheet. If a mixture of radionuclides is present, the DAC used in the calculations of DAC-hours will be the most restrictive concentration.

7.2.8 Collect the sample for the amount of time which represents the exposure encountered by the worker.

7.2.9 At the end of the collection period, record the flow rate and time off of the sample pump on the Air Sample Data Sheet. Collection times must be sufficient to achieve required minimum detectable activity (MDA)/minimum detectable concentrations (MDCs) for the radioisotope(s) of concern.

CAUTION: Be sure not to remove activity from the sample surface. Handle the filter with care (tweezers should be used if possible).

7.2.10 Remove the sample filter and place the filter in an individual envelope or poly bag to ensure no possibility of contamination by other sources of radioactivity.

7.2.11 Record the names of workers who were in the area and the time spent in the work area on Attachment B, Daily Air Sample Record. Approved electronic templates may be used in place of this form as long as the equivalent information is provided, as described in this procedure.

7.2.12 Determine the average sample flow rate by adding the initial sample flow rate and the final sample flow rate and dividing by two. Record the average flow sample flow rate in the space provided on the Air Sample Data Sheet.

7.2.13 Calculate the total air volume sampled by multiplying the average flow rate in cubic centimeters per minute by the total minutes the sampler operated using the indicated spaces on the Air Sample Data Sheet.

7.2.14 To verify that the air sampling activity will meet data quality objectives (before or after sampling), the Minimum Detectable Concentration (MDC) may be calculated using the following formulae:

$$MDC\ in\ \mu Ci/cm^3\ = \frac{\frac{k_\alpha^2}{T_s} + 2[k_\alpha]\sqrt{\frac{R_b}{T_b} + \frac{R_b}{T_s}}}{(2.22 \times 10^6)(E)(V)}$$

Where:

E_T =	Total Efficiency (c/d); the product of the Instrument Efficiency (E_I) and Source Efficiency (E_S) values.
R_b =	Background Count Rate in cpm (alpha or beta)
T_b =	Background Counting Time in Minutes
T_s =	Sample Counting Time in Minutes
V =	Collected Sample Volume in cm^3
$2.22X10^6$ =	Disintegrations per minute per microcurie (dpm/µCi)
K_α =	1.645 for a confidence level of 95% and 1.96 for a confidence level of 99%

7.2.15 If the MDA is larger than 10% of the DAC (or other value, as directed by the RSO), recount the background for a longer time and/or increase the sample count time to lower the MDA. The maximum count time should not exceed 1 hour for background and 30 minutes for the sample. Enter the MDA for each air concentration calculated in the space provided on the Air Sample.

7.3 Air Sample Evaluation and Dose Assignment

7.3.1 In situations where there is a potential for worker intakes to exceed 40 DAC-hours in a week, or if the radionuclides of interest are short-lived, air sample results should be available before work resumes the following day.

7.3.2 When practicable given data needs, allow samples to decay for at least four hours prior to counting to allow for decay of short-lived radon/thoron daughters from naturally occurring sources.

7.3.3 Air particulate samples should be counted using the instrumentation appropriate for the expected levels and radionuclide emissions. For non-emergency situations, the best equipment are AC-powered scintillation/proportional counters with stable backgrounds and counting conditions. Field instruments may be used in emergency situations, as directed by the RSO.

7.3.4 Although not “required” for sites with no alpha emitter concerns, gross alpha counting results may support radon/thoron false-positive determinations.

7.3.5 The Decision Level (DL) may be calculated to assess actual results against expected background and make “non-detect” determinations for individual samples using the following formula:

$$DL\ in\ \mu Ci/cm^3 = \frac{2[k_\alpha]\sqrt{R_b\left(\frac{1}{T_b}+\frac{1}{T_S}\right)}}{(2.22\times 10^6)(E)(V)}$$

Where:

E_T =	Total Efficiency (c/d); the product of the Instrument Efficiency (E_I) and Source Efficiency (E_S) values.
R_b =	Background Count Rate in cpm
T_b =	Background Counting Time in Minutes
T_s =	Sample Counting Time in Minutes
V =	Sample Volume in cm^3
$2.22X10^6$ =	Disintegrations per minute per microcurie (dpm/µCi)
K_α =	1.645 for a confidence level of 95% and 1.96 for a confidence level of 99%

7.3.6 Place the air sample collection media in the sample counter with the upstream collection side toward the detector. Count the air sample and calculate the sample activity and record results on appropriate form(s).

7.3.7 Record the alpha and beta sample dpm results in the Air Sample Data Sheet.

7.3.8 Calculate the alpha and beta air concentrations using the following formula. Adjustments due to alpha self-absorption are made, as appropriate.

$$\text{Air Concentration } (\mu Ci/cc) = \frac{DPM\ (\alpha\ or\ \beta)}{(2.22 \times 10^{6} DPM/\mu Ci)(SampleVolume(cm^3))}$$

7.3.9 Enter the alpha and beta air concentrations on the Air Sample Data Sheet in the space provided for the initial air concentrations.

7.3.10 Air concentrations below the DL with an MDC <10% DAC, are considered “non-detectable”; record the results - no further actions are typically.

7.3.11 If the air concentration is <10% DAC, no further analysis of the air sample is required unless; additional actions may be directed by the AU/RSO for ALARA purposes.

7.3.12 If the air concentration >10% DAC, notify the AU or RSO and consider recounts to assess the potential for impact from short-lived natural decay products (when suspected). Changes to area postings, controls, or individual monitoring approaches may be required based on initial results depending on work activities and current protective clothing levels.

7.3.13 Initial counts or recounts may be recorded in sample analysis records at the direction of the AU/RSO; the final record count (pre- or post-decay) shall be documented in survey records (or results workbooks). For “final” counts:

- If the air concentration is below the DL and <10% of the DAC value, no further analysis is required.

- If the air concentrations exceed 10% of the DAC values, notify the RSO or authorized representative for further instructions. Save the air sample for possible further analysis.
- For air samples, which exceed 10% of the DAC values, an intake is typically assigned to the workers residing in the area where the sample was taken. Bioassay may be considered for longer term projects where worker intakes are expected to exceed 0.5 rem/year Committed Effective Dose. If bioassay is not conducted, breathing zone lapel sampling will be used first to assign individual doses before consideration of work zone sampling results.

7.3.14 The RSO may direct alternate sampling and counting regimes that offer more accurate assessment of air concentrations and meet regulatory objectives.

7.4 Assignment of Dose from Air Sampling (Typical Approach)

DAC values are derived from values published in 10 CFR § 20 (Appendix B), 10 CFR § 835 (Appendices A & C) or Agreement State regulations, as applicable (See References). For mixtures of contaminants including difficult-to-detect radionuclides, derived DAC values based on relative ratios may be determined and used; consult with the AU/RSO for guidance.

7.4.1 For air samples which exceed 10% of the DAC values, calculate the workers DAC-hour exposure using the following formula to assess if monitoring thresholds may be exceeded and that individual dose limits are not exceeded:

$$\text{Exposure in DAC-hours} = \frac{A \times B}{C}$$

Where:

A = Area or lapel air sample concentration in microcurie per cubic centimeter (µCi/cm^3)

B = Hours worker was in the calculated air concentration

C = DAC air concentration in µCi/cm^3 from regulatory reference.

7.4.2 Enter the DAC-hour exposure on the column provided on the Air Sample Data Sheet. If respiratory protection was used during the exposure period, contact the RSO or authorized representative for the protection factor used to adjust DAC-hour exposure.

7.4.3 For normal exposure scenarios, 1 DAC-hr intake equals 2.5 millirem committed effective dose

7.5 Bioassay

Bioassay is not typically used for work at Cabrera temporary job sites unless threshold requirements for individual worker monitoring are met and, bioassay is determined by the RSO to be the most effective means of

estimating dose. Bioassay program needs and elements (methods, frequencies, interpretations of results, etc.) are developed on a case-by-case basis in consultation with a Certified Health Physicist or experienced internal dosimetrist with a minimum of five years-experience conducting similar evaluations. Bioassay requirements for a temporary job site are typically addressed in the site-specific work control documents.

Bioassays should be considered for specific workers who will have their internal dose individually monitored by regulation AND have received previous intakes from isotopes consistent with radionuclides of concern at the temporary job site.

Bioassays maybe be directed by the RSO prior to or upon field mobilization (Baseline bioassay), under circumstances where an intake is expected, at routine intervals, and upon termination of required internal dose monitoring.

7.5.1 Urine analysis

Urine samples will normally consist of collecting samples over a 24-hour with a minimum sample volume of 1-liter but may be changed per need of the testing laboratory or medical facility.

a. Urine samples shall be labeled on the bottle with, at a minimum:

- The name of the project or facility
- Indication as to whether it is an entry or exit sample
- The date of sampling
- The name of the individual providing the sample
- The social security number (SSN) of the person providing the sample
- The date of birth of the person providing the sample

b. The form shall be attached to the bottle to prevent samples from being inadvertently exchanged.

c. Using OP-3203, *Chain of Custody*, record all required information to ensure control of a proper analysis of the sample(s).

7.5.2 Fecal Analysis

Utilization of fecal sample and analysis will be determined by RSO on case-by-case basis. Consideration for subitizing urine analysis or whole-body counting should be given to radionuclide(s) biochemistry, excretion pathway(s) and biological half-life(s).

7.5.3 In Vivo Whole-Body Count

A whole-body count (an in vivo bioassay method) should be considered first when assessing intakes of radionuclides readily measurable by gamma methods.

7.5.4 Emergency Bioassay Procedures

Immediate Evaluation

If there is radioactive material on or around the face, nose, or mouth, take a nasal smear. If radioactive material in/around a wound, take a smear around the wound. Determination for smearing near a wound will be made by RSO or authorized representative. Immediate evaluation should not take precedence over emergency medical attention or the safety of the victims and the responding staff.

a. The nasal smear or smear shall be counted on a portable survey instrument or smear counter (preferred) to determine the extent of contamination, as well as, to determine the emission type and estimated activity levels; refer to applicable instrument counting/survey procedures and report any detectable activity above background to the RSO immediately

b. Documentation of bioassay data is critical to ensuring that a complete and proper dose analysis can be made. The information must be as accurate as possible. Following an emergency bioassay procedure, the following should be recorded:

   - Time and date of the event
   - A discussion of the events leading to the emergency, the results of initial and current surveys of the personnel involved.
   - The initial levels of contamination, radiation dose, chemical exposure, and any information concerning decontamination that may be available.

c. If the radionuclide(s) are a pure alpha or beta particle emitter, a urine or fecal analysis (RSO determination) is required.

   - Collect the required milliliters of urine using the steps outlined in Section 7.5.3. Fecal matter sampling will be based on laboratory or medical facility requirements.
   - Collect a sample for each effective half-life interval for the radionuclides of interest, totaling three consecutive effective half-lives. This collection frequency determines radionuclide clearance rate.
   - Forward urine samples or fecal samples to a laboratory or medical facility. Forward all pertinent information as necessary for the analysis to be completed.

d. For contamination involving transuranic compounds, a chest (lung) count in the first 12 hours following the event and a subsequent count 24 hours after the initial count will facilitate adequate determination of the intake.

7.5.5 If contamination is a gamma emitter, analyze the activity in the body by performing a whole-body count at a certified laboratory or medical facility.

7.6 Assignment of Dose from Bioassay

Perform review of bioassay results from certified laboratory or medical facility. If assay results indicated radioisotope(s) not identified by site work documents, contact RSO for further guidance.

Calculate CDE and CEDE from analysis results, refer to Reg Guide 8.34, *Monitoring Criteria and Methods to Calculate Occupational Radiation Doses*. Consult RSO for further guidance involving CDE and CEDE determination.

Place the analysis results, as provided by the laboratory, and the calculated committed dose equivalent and committed effective dose equivalent in the worker's exposure file.

The RSO or authorized representative shall review all documentation associated with the accidental exposure and develop a report for the individual's file to indicate internal and external dose equivalent. If AU performs review, RSO concurrence is needed.

8.0 REFERENCES

- 10 CFR § 20, *Standards for Protection Against Radiation*
- 10 CFR § 835, *Occupational Radiation Protection Program*
- 10 NYCRR § 16.6, *Occupation Dose Limits*
- 10 NYCRR § 16.11, *Personnel Monitoring*
- 10 NYCRR § 16.14, *Records*
- 12 NYCRR § 38.18, *Occupation Dose Limits*
- 12 NYCRR § 38.24, *Personnel Monitoring*
- 12 NYCRR § 38.28, *Records*
- 17 CCR § 30253, *Standards for Protection Against Radiation*
- U.S. Nuclear Regulatory Commission, *Air Sampling in the Workplace,* Regulatory Guide 8.25, (1992).
- U.S. Nuclear Regulatory Commission*, Monitoring Criteria and Methods to Calculate Occupational Radiation*, Regulatory Guide 8.34, (1992).
- U.S. Nuclear Regulatory Commission, *Air Sampling in the Workplace*, NUREG-1400, (1993).
- OP-3407, *HP Instrument General Quality Control Procedure*
- OP-3410, *Alpha-Beta Counting Instrumentation*.
- OP-3601, *Radiological Surveys*

9.0 REQUIRED RECORDS

9.1 Quality Assurance

Instrumentation used in surveys required by this procedure shall be checked with standards daily and verified to have current valid calibration in

accordance with OP-3401, *Health Physics Instrument General Quality Control*

This effectiveness of the Internal Dosimetry Program and conformance with governing program documents is assessed as part of periodic radiation safety program reviews (and associated records).

9.2 Records

Documented information shall be legible written in ink.

Data shall not be obliterated by erasing, using white-out, or by any other means. Incorrect entries shall be corrected by striking a single line across the entry. The correction shall be entered, initialed, and dated.

All records of exposure are legal and personal and must be controlled as such.

All records generated by this procedure may be required to demonstrate compliance with state and federal requirements and shall be maintained in accordance with these requirements.

The RSSS using this procedure shall ensure that it is the most current and approved revision.

The RSSS/AU performing an air sample or bioassay shall review any applicable forms for accuracy and completeness.

Entries on any pertinent forms must be dated and initialed RSSS/AU performing the activity to be valid.

The RSO or his designee shall review any applicable completed forms for accuracy and completeness.

10.0 ATTACHMENTS

The following attachments are provided as examples. RSO or AU will provide an electronic forms or physical forms. RSO may authorize use of alternate versions provided equivalent required information is included.

- Attachment A – Example Air Sample Data Sheet
- Attachment B – Example Daily Air Sample Record
- Attachment C – Example Bioassay Label

Attachment A
Example Air Sample Data Sheet

Example Air Sample Data Sheet

Sample # _____ Date _____

Description: _____

Radionuclides: _____ DAC value: _____

_____ DAC value: _____

_____ DAC value: _____

Initial sample flow rate: _____ Time sampler on: _____

Final sample flow rate: _____ Time sampler off: _____

Average sample flow rate: _____ Total sample time: _____ hours

Total sample volume: _____ cm^3

30 min Air Concentration:

Alpha = _____ $\mu Ci\ \alpha/cm^3$ Beta = _____ $\mu Ci\ \beta/cm^3$

MDA = _____ $\mu Ci\ \alpha/cm^3$ MDA = _____ $\mu Ci\ \beta/cm^3$

4 Hour Decay Air Concentration:

Alpha = _____ $\mu Ci\ \alpha/cm^3$ Beta = _____ $\mu Ci\ \beta/cm^3$

MDA = _____ $\mu Ci\ \alpha/cm^3$ MDA = _____ $\mu Ci\ \beta/cm^3$

24 Hour Decay Concentration:

Alpha = _____ $\mu Ci\ \alpha/cm^3$ Beta = _____ $\mu Ci\ \beta/cm^3$

MDA = _____ $\mu Ci\ \alpha/cm^3$ MDA = _____ $\mu Ci\ \beta/cm^3$

Attachment B
Example Daily Air Sample Record

Example Daily Air Sample Record

Worker Name	Sample Date	Count Date	Time In	Time out	Total time (Hrs.)	Concentration ($\mu Ci/cm^3$)	DAC-Hour Exposure

Attachment C
Example Bioassay Label

Example Bioassay Label

The label affixed to a bioassay sample should be sized to fit the container in which the sample is stored and shipped. This is an example of a 3" x 1.5" label, which could be used to identify a 100 ml urine sample

Name: Sample Date:	
SSN:	DOB:
Type of Sample:	Entry/Exit/Other:
Project Name:	Proj. Mgr. Result to: