DEBRIS REMOVAL PLAN – BUILDINGS 3H/6H

Site Decommissioning Former UNC Manufacturing Facility
New Haven, Connecticut

Submitted to

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1.0 INTRODUCTION

Cabrera Services Inc. (Cabrera) has been contracted by United Nuclear Corporation (UNC) Naval Products to coordinate and perform the removal of miscellaneous debris, drums, and other obstructions to performing a complete radiological survey of the floors in Building 3H/6H at 71 Shelton Avenue in New Haven, Connecticut, hereafter referred to as the "Site". The purpose of this debris removal is as follows:

- Allow Cabrera to complete a characterization survey of 100% of the floor areas within the H-Tract building, known as Building 3H/6H;
- Substantially reduce the safety hazard inside the building caused by asbestos containing material (ACM) in the roof debris that has fallen to the floor in Building 3H;
- Survey and release debris and other items (i.e., drums) that are not radiologically contaminated for disposal at an off-site non-radiological landfill; and
- Package, transport, and dispose of radiological wastes from the building in an off-site landfill capable of accepting radiological wastes.

The location of the Site is displayed in Figure 1 in Appendix A. These tasks will be completed in accordance with Cabrera's *Accident Prevention Plan* (APP; Cabrera, 2014a), *Nuclear Material Control and Accountability Plan* (Cabrera, 2010), and *Radiation Safety Program Manual, Revision 2* and licensed procedures (Cabrera, 2014b).

1.1 SITE DESCRIPTION AND HISTORY

The former UNC Naval Facility was originally operated by Olin Mathieson Chemical Corporation – Winchester Western Division (Olin) from April 1956 to May 31, 1961 and by UNC from June 8, 1961 to April 22, 1976. Specifically, Olin operated as a contractor from 1956 to 1960, and obtained an Atomic Energy Commission (AEC) (later United States Nuclear Regulatory Commission [USNRC]) special nuclear material license (license number SNM-368; Docket Number 07000371) in 1960 for fabrication and manufacture of reactor fuel components for the Naval Reactors Program in New Haven, CT at Building 3H/6H. On May 31, 1961, Olin transferred these assets to United Nuclear – Fuels Division. On June 8, 1961, the USNRC re-issued SNM-368 to United Nuclear – Fuels Division, which later became known as United Nuclear Corporation Naval Products (UNC). This license authorized possession and use of enriched uranium and source materials, including natural uranium, depleted uranium, and thorium for research and nuclear fuel fabrication. The radioactive material used in these operations was primarily enriched uranium and natural uranium.

In 1974, UNC announced the closing of Building 3H/6H and transferred their inventory of radioactive materials from the New Haven, CT location to the Montville, CT location. Final surveys of the New Haven facility were completed by February 1976 and the USNRC performed confirmatory surveys from March 8 to 10, 1976. On April 22, 1976, the USNRC amended the SNM-368 license to remove the New Haven facility from the license. The site was released for unrestricted use in accordance with the existing regulations and guidance.

The SNM-368 license was terminated on June 8, 1994, following the decontamination and decommissioning of the Montville site. The USNRC's guidance and criteria for release for unrestricted use, at that time, was Regulatory Guide 1.86, dated June 1974, and "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted use or Termination of Licenses for Byproduct, Source or Special Nuclear Material," dated May 3, 1973. At about the same time the SNM license was terminated, the USNRC initiated a "Terminated Sites Review Project" to ensure that formerly licensed facilities by the AEC and/or the USNRC were terminated in accordance with current USNRC criteria for release for unrestricted use. As part of the Terminated Sites Review Project, the USNRC's contractor, Oak Ridge National Laboratory, identified the retired SNM-368 license as requiring additional review because final radiological survey records were either incomplete or inadequate. USNRC Region I staff reviewed this assessment and determined further information on this site was necessary to conclude that the facility met the current criteria for release for unrestricted use.

Therefore, the USNRC and the USNRC's contractor, Oak Ridge Institute for Science and Education (ORISE), conducted an independent measurements inspection in September 1996 using the release criteria in 1981 Branch Technical Position "Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations", published in the Federal Register on October 23, 1981 (USNRC, 1981). The results of this inspection indicated that residual enriched uranium, in certain areas inside the building and inside a connected inactive sewer system, had exceeded the release criteria of 30 picocuries per gram (pCi/g) in soil. These contaminated areas were documented in the USNRC Inspection Report and in the ORISE "Radiological Scoping Survey of Buildings 3H and 6H at the former UNC H-Tract Facility, New Haven, Connecticut."

Based on the results of this inspection and additional information provided by UNC, the USNRC determined that more soil testing was necessary. This testing was performed by UNC on February 12, 1997. The results of the soil testing showed that a small number of local areas of soil and sediment contained enriched uranium exceeding the soil acceptance criteria established by the USNRC in 1981. These areas showed total uranium levels up to 723 pCi/g, exceeding the USNRC release criteria of 30 pCi/g. During the decontamination and decommissioning activities of 1973 to 1976 there were no published soil release criteria other than "as low as reasonably achievable" (ALARA), and meter surveys of the soil by a USNRC inspector in 1976 were found to be acceptable.

UNC developed and provided to the USNRC a characterization report that described the sampling and testing performed in 2003. A Decontamination and Decommissioning Plan was developed and submitted to the USNRC in June 2005 to remove the soil with a total uranium concentration greater than 30 pCi/g.

Limited FSS operations of impacted land areas, exterior surfaces, and structures were completed by Cabrera from 2011 to 2012. These operations provided evidence that the soils beneath utility trenches underlying Building 3H/6H required additional characterization and possibly remediation of residual radioactive contamination. Cabrera investigated the extent of contamination in soil beneath the trenches in a follow-up investigation in the fall of 2014. This survey effort did not find widespread evidence of contamination exceeding the $DCGL_W$ in soils beneath the Building 3H/6H. The extent of the contamination exceeding the $DCGL_W$ is most likely limited to the areas immediately around and under drainage holes that are presented in the floor of the South Trench (Cabrera, 2015).

The site is located at 71 Shelton Avenue, New Haven, CT and consists of Building 3H/6H and a connected, but inactive, sewer system that traverses an adjacent private property line. The building is constructed of concrete floors, concrete/cinder block walls and a wooden roof. A chain link fence completely surrounds the site. The south side of the building, which borders Argyle Street, is currently owned by Olin and is overgrown with vegetation. A second chain link fence surrounds the adjacent private property. This fence separates the adjacent private property and Argyle Street. There is an inactive sewer line that lies under Argyle Street, traverses under the property line (and chain link fence) of the adjacent private residence, and ends under Shelton Avenue.

1.2 PURPOSE

Cabrera mobilized to the Site in June 2016 to perform a supplemental characterization survey of three areas:

- Accessible floor areas within the H-Tract building, known as Building 3H/6H,
- Intact ductwork within Building 3H and;
- Subsurface soils underneath former Buildings 9H/10H/11H.

During the floor scanning survey, several metallic radioactive items were discovered in Building 3H on the floors, often in and around piles of dirt and debris. Cabrera mobilized a portable gamma spectroscopy detector to the project site and confirmed the items contained HEU. After conferring with UNC, DOE, NRC, and other project stakeholders, it was decided that a complete survey of the floor would have to be performed to determine the extent of potential radioactive contamination on the floor. In order to complete this survey, the debris would have to be completely removed from the building and either stored or disposed off-site until the survey could be completed. A comprehensive project schedule is provided in Appendix B.

1.3 RADIONUCLIDES OF CONCERN

Table 1-1 presents the radionuclides of concern (ROCs) for the Site. Thorium was dismissed as a radionuclide of concern through the use of process knowledge; process knowledge confirmed that the historic use of thorium on-site was far too limited to consider it a radionuclide of concern.

TABLE 1-1. RADIONUCLIDES OF CONCERN

Radionuclide	Half-Life	Principal Emissions
Uranium-234	2.45E+05 years	4.72, 4.77 MeV alpha; 0.053 MeV gamma
Uranium-235	7.04E+08 years	4.39, 4.36 MeV alpha; 0.18, 0.14 MeV gamma
Uranium-238	4.47E+09 years	4.19, 4.14 MeV alpha; 0.049 MeV gamma
MeV = mega-electron-volt		

2.0 ORGANIZATION AND RESPONSIBILITIES

This Section describes the project organization and responsibilities personnel directing and performing remediation. Figure 2-1 presents the project organization chart.

2.1 UNC NAVAL PRODUCTS RESPONSIBILITIES

UNC contracting authority is Mr. John Uruskyj. All communication regarding cost, schedule, and scope will be directed through Mr. Uruskyj. UNC is also responsible for site activity coordination with the property owner.

2.2 CABRERA RESPONSIBILITIES AND PERSONNEL

2.2.1 Project Manager

Cabrera's Project Manager (PM) will be Mr. Rob Flowers. He is responsible for evaluating the appropriateness and adequacy of the technical services provided for the project, and for developing the technical approaches and level of effort required to address each task. He is also responsible for the day-to-day conduct of work, including integration of input from supporting disciplines. He will work closely with Cabrera's Site Manager (SM) during field work. Specific responsibilities include:

- Initiating project planning and directing project activities;
- Ensuring that qualified technical personnel are assigned to various tasks, including subcontractors;
- Identifying and fulfilling equipment and other resource requirements;
- Monitoring project activities to ensure compliance with established scopes, schedules, and budgets;
- Ensuring overall technical quality and consistency of all project activities and deliverables; and
- Serving as the primary Cabrera POC with the UNC Naval Products.

Cabrera's PM and SM have overall responsibility for ensuring that all activities are performed in accordance with NRC and Connecticut Department of Energy and Environmental Protection (CTDEEP) requirements, as well as those of this Work Plan and supporting project documents.

2.2.2 Corporate Quality Assurance Manager

Mr. Sean Liddy, the Corporate Quality Assurance Manager (QAM), is responsible for the quality of Cabrera's work. The Corporate QAM will be responsible for assuring the project team implements the applicable policies and procedures and assuring that corrective action is taken if performance does not meet internal quality requirements. The Corporate QAM will work closely with the Cabrera PM and SM to ensure that established protocols and procedures

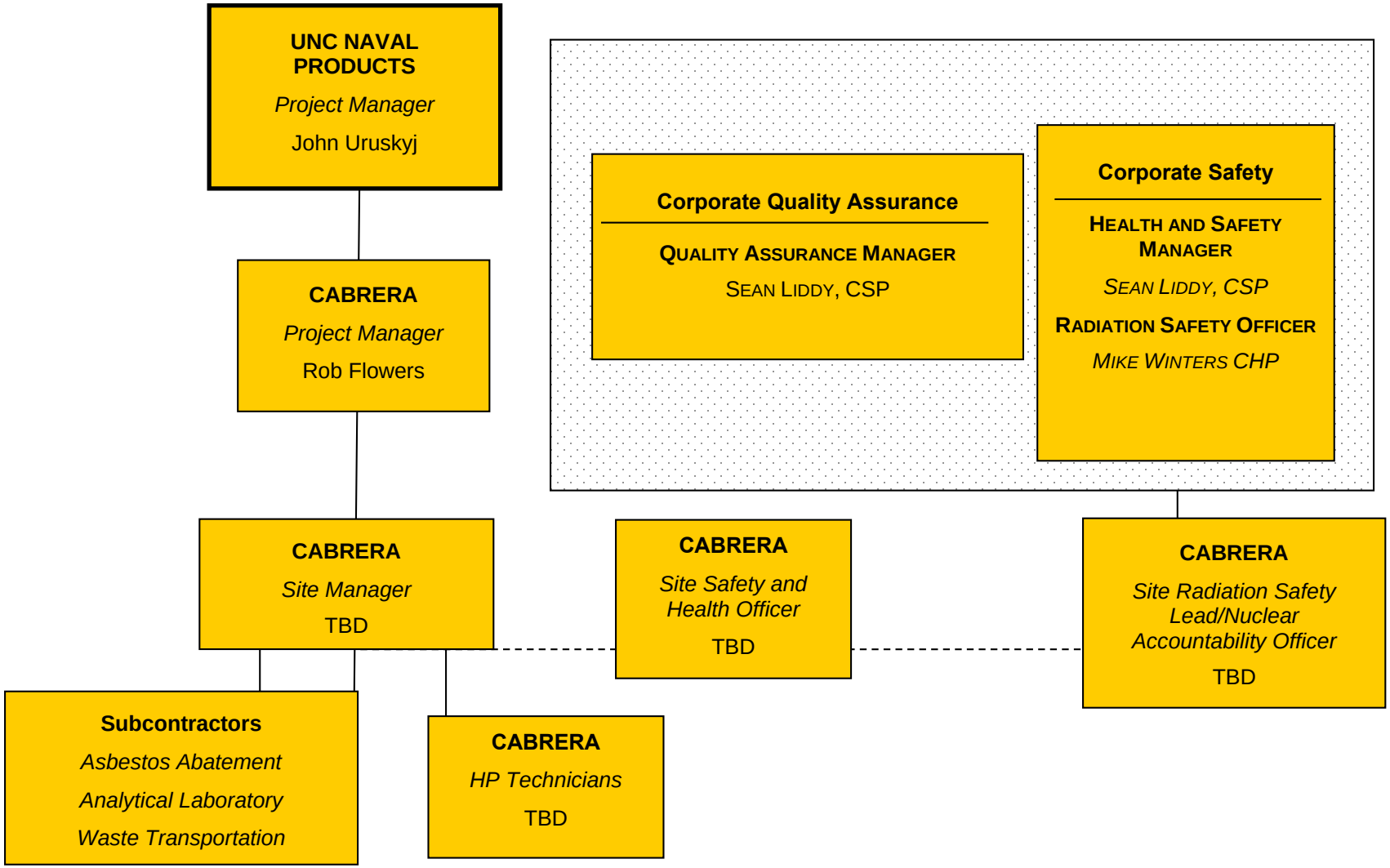

FIGURE 2-1: PROJECT ORGANIZATIONAL CHART

are implemented, and that the work is performed in accordance with this Work Plan and other supporting project documents.

The QAM is responsible for directing planning, implementing, and tracking quality control (QC) activities and maintaining internal communication on QC matters. The Corporate QAM, or designee, may conduct periodic site and project audits as part of this process. He may conduct periodic audits of on-site procedures, including safety procedures. The duties also include QC task staffing; and ensuring that quality control, data evaluation, data verification, and reporting procedures are followed.

2.2.3 Corporate Radiation Safety Officer/Health Physicist

Mr. Mike Winters, Certified Health Physicist (CHP) is Cabrera's Corporate Radiation Safety Officer (RSO) and Health Physicist (HP). In that capacity, he is responsible for oversight and review of all Cabrera radiological activities and data. The Corporate RSO/HP has the authority to direct such activities, stop work (and restart based on consultation with the PM) and to take appropriate actions, as required, to address radiological emergency situations. He will work directly with the SM, Site Safety and Health Officer (SSHO), Project Health Physicist (HP) and Site Radiation Safety Lead (SRSL) to ensure that the Cabrera *Radiation Protection Plan* (RPP) and Nuclear Material Accountability Plan are properly implemented and followed. The RPP is Appendix A of the *Accident Prevention Plan* (APP) (Cabrera, 2009).

2.2.4 Corporate Health and Safety Manager

Cabrera's Corporate Health and Safety Manager, Mr. Sean Liddy, Certified Safety Professional (CSP) is responsible for Cabrera's overall health and safety program. His duties in that capacity include development of procedures, providing/coordinating health and safety training, review and approval of project/site-specific APPs and revisions thereof, working with PMs and SMs to ensure sufficient resources are planned and provided to implement APPs, serve as an internal safety and industrial hygiene consultant and resource to SSHOs as well as PMs and SMs in evaluating and recommending safe practices, and performing internal audits to verify proper implementation of APPs.

2.2.5 Site Manager

The SM reports directly to the PM and is responsible for the overall direction and management of field work associated with the debris removal. This includes oversight of field staff and subcontractors and ensuring that procedures for field activities are executed in the proper manner, activities are properly documented, the prescribed planned work activities are completed, and communication protocols are followed.

The SM is responsible for managing the removal and waste packaging/transportation activities in accordance with this work plan and supporting project plans. The SM will monitor work progress and schedule, advise the PM of variances, and assist in the preparation of work progress schedules, project reports, drawings, and required compliance submittals. The SM will be on site during decontamination and site restoration field work.

2.2.6 Site Safety and Health Officer

The project SSHO reports directly to Cabrera's Corporate Health & Safety Manager. The SSHO communicates and coordinates with the PM and SM. The SSHO is responsible for verifying the APP (Cabrera, 2014a) is followed and that project personnel are appropriately trained as required. The SSHO has authority to issue stop work orders for on-site tasks that he/she believes may be unsafe. When stopped, work will not recommence until the Corporate Health & Safety Manager, Corporate RSO/HP (as applicable), and PM approve the restart.

The SSHO is also responsible for maintaining personnel training certificates, medical monitoring files (as needed), and preparing accident investigation forms in accordance with the accident avoidance and reporting procedures of the APP (Cabrera, 2104a).

2.2.7 Site Radiation Safety Lead/Nuclear Accountability Officer

The Site Radiation Safety Lead/Nuclear Accountability Officer (SRSL) is responsible for ensuring that radiation safety procedures designed to protect Site personnel and the public are maintained throughout the project. The SRSL is responsible for ensuring the requirements in the RPP (Cabrera, 2014b) are addressed for the duration of the project. He is also responsible for reviewing radiological data deliverables from analytical laboratories, interfacing with the laboratory client services coordinators, and coordinating the resolution of laboratory problems. The roles and responsibilities of the SRSL are further defined in the project APP (Cabrera, 2014a).

The SRSL will also be responsible for overseeing the maintenance and quality control checks of the on-site radiological instruments.

The SRSL will provide field laboratory results for use by the Waste Manager to prepare waste profile sheets, characterizing waste and preparation of shipping documentation for UNC approval. The SRSL will be on site during decontamination and restoration activities including shipment of waste for offsite disposal.

2.2.8 Field Team

Cabrera Field Team members are responsible for performing field activities described in this Plan. In addition to the field personnel listed above, the field team members and responsibilities will consist of HP Technician(s), who will report to the SRSL and will perform periodic instrument checks, perform radiological surveys [e.g., of intermodal containers, debris, equipment, and work areas), and collect and prepare samples for off-site laboratory analysis. The HP Technician(s) will also maintain radiological control areas (RCAs) and controls, perform surveys of personnel and equipment, complete instrument and data records, log data, maintain documentation, and perform instrument QC functions in an on-site radiological laboratory during field activities, with oversight by the SRSL.

2.3 SUBCONTRACTORS

Subcontractor services will include asbestos abatement, off-site laboratory analyses, support services, transportation, and disposal services.

2.3.1 Off-Site Analytical Laboratory

The chosen off-site laboratory will be sent samples for waste characterization purposes.

2.3.2 Support Services

Support services will be required to complete the scope of this project and will include following:

- Asbestos Abatement – A Connecticut asbestos abatement contractor will be selected to abate the asbestos in the debris piles.
- Waste Transportation – A Waste Transportation subcontractor will provide IMCs to the project, and will coordinate shipping filled IMCs to the chosen waste disposal facility (EnergySolutions).

2.3.3 Transport and Disposal of Radiologically Contaminated Debris

Radiologically-contaminated debris and soil will be transported to an off-site disposal facility. Radioactive waste containers prepared for the transport of debris and soil will initially be transported by truck to a local trans-load facility for further transport by qualified, permitted transportation subcontractors to EnergySolutions in Clive, Utah by rail or truck.

3.0 PROJECT ACTIVITIES

3.1 PRE-MOBILIZATION ACTIVITIES

This section describes project-related tasks that will be completed prior to full field mobilization.

3.1.1 Site Specific Project Work Plans

Site-specific project work plans have been developed and will be used to support this sampling effort. The most current approved revision for each document will be maintained on-site, at Cabrera's project field office, in addition to applicable Cabrera standard Administrative and Operating procedures. A description of applicable Cabrera standard APs and OPs is provided in Table 3-1.

TABLE 3-1. APPLICABLE CABRERA STANDARD OPERATING PROCEDURES

REFERENCE NUMBER	TITLE, REVISION NUMBER
AP-005	ALARA, Rev. 2
AP-009	Radiation Worker Training, Rev. 2
AP-010	Personnel Protective Equipment Used Within Radiological Controlled Areas, Rev. 1
AP-013	Packaging Radioactive Material, Rev. 0
AP-014	Classifying Radioactive Waste, Rev. 0
AP-016	Radioactive Material Tracking, Rev. 0
OP-001	Radiological Surveys, Rev. 3
OP-002	Radioactive Air Sampling and Analysis, Rev. 1
OP-004	Unconditional Release of Materials from Radiological Control Area, Rev. 2
OP-005	Volumetric and Material Sampling Within Radiological Control Areas, Rev. 2
OP-008	Chain of Custody, Rev.1
OP-009	Use and Control of Radioactive Sources, Rev. 1
OP-018	Decontamination of Radioactivity from Equipment and Tools, Rev. 1
OP-019	Radiological Posting, Rev. 0
OP-021	Alpha-Beta Counting Instrumentation, Rev. 1
OP-023	Operation of micro-R meters, Rev. 0
OP-362	Sample Management & Shipping, Rev. 2.0

REFERENCE NUMBER	TITLE, REVISION NUMBER
OP-428	Preparation of Samples for Gamma Spectroscopy, Rev. 1
OP-429	Gamma Spectroscopy Operations, Rev. 5
OP-468	Sample Management - Onsite Laboratory Rev. 1

These procedures are attached to this plan in Appendix C.

3.1.2 Procuring Equipment, Materials, and Specialty Services

An asbestos abatement contractor licensed in the state of Connecticut will be selected to abate the piles of soil/debris materials that contain ACM in Building 3H. A laboratory subcontractor will be procured for the off-site waste characterization sampling. A waste transportation subcontractor will be procured to furnish empty IMCs for the project, and transport filled IMCs from the Site to the disposal facility.

3.1.3 Notifications

Cabrera will make appropriate notification to the NRC and to the state of Connecticut Department of Public Health (CDPH) before beginning work on-site. This work will be performed under Cabrera's current NRC license. Notifications will be made to the NRC and CDPH at least 10 days working prior to beginning work on-site.

3.2 FIELD ACTIVITIES

This section describes field activities that will be completed during this portion of the project.

3.2.1 Mobilization and Site Preparation

It is anticipated that the mobilization and site preparation activities will require approximately two days and will include:

- Personnel travel to the Site;
- Review project plans with site personnel;
- Conduct required site-specific training;
- Set-up project offices and support facilities;
- Establishing paths of travel and posting construction signs and Radiological Control Areas (RCAs); and

Performing initial quality control checks of field radiological instrumentation

3.2.2 Asbestos Abatement

The roofing material in Building 3H/6H has been analyzed during previous phases of work, and contains ACM. There are several areas of the building in which roofing material has fallen to the ground, and is in various states of disturbance, or is mixed with dirt and dust piles. Examples of these areas include the eastern end of Building 3H, and the room between the Decon Pit and the X-Ray Read Room (see Figure 2 in Appendix A). Areas of dirt and debris that have roofing material containing asbestos mixed in it will require abatement under asbestos controls, including, but not limited to, containment with negative pressure and HEPA filtration. Only trained asbestos workers will be permitted in active containment areas. All dirt containing asbestos will be wetted-down, double-bagged, taped, and marked as containing ACM prior to being released from the containment area. All debris will be wrapped to be put inside the IMC, or, if possible, wiped down and cleaned of potential ACM dust, and surveyed for radioactivity. If possible, abatement activities will be expedited by constructing the containment large enough to allow for:

1) Heavy equipment, such as a skidsteer track loader with a bucket and/or grapple, to be able to maneuver and sort through the pile and pick out debris, and
2) An empty IMC to be staged in the area and be directly loaded, rather than passing the bagged ACM out of the area and loading at a different location.

Asbestos abatement activities associated with the piles of dirt and debris will be performed using the wet method and bagging/wrapping the asbestos material. After the piles are removed, the floor of the containment will be HEPA vacuumed to remove as much dust and dirt as possible.

There are other areas in the building where dirt and dust coat most surfaces, including the floor, walls, and equipment, and these areas may require asbestos abatement prior to the removal of debris (see Figure 2 in Appendix A). Cabrera's asbestos abatement subcontractor, AIG, will mobilize an Industrial Hygienist (IH) to collect swipe samples of dust in these areas to determine if asbestos abatement will be required (as described above) or if the dust does not contain asbestos and can simply be broom swept, vacuumed, or cleaned without asbestos controls in place. After receiving the results of these analyses, the IH will develop an Alternative Work Practice (AWP) describing the planned means and methods for abating the asbestos hazard as required for removal of the debris from the building for review and approval by CDPH. Mobilization will not occur until CDPH approval of the AWP is received, and AIG submits the subsequent notification to CDPH of the work being performed.

It will not be possible to prevent infiltration of rainwater given the poor condition of the roof. Work will begin in one section of the building (e.g. the eastern end of Building 3H); as work is completed in one section, ACM work will start in the next section in accordance with the approved abatement plan. A containment with a plastic, temporary roof will be constructed to prevent roofing material from falling inside the area during abatement. After abatement is completed, and the IH has approved the area is free of ACM, debris removal work will continue with the temporary roof in place. After debris removal is completed, the remaining characterization surveys will be performed as required. Finally, the temporary roof and other plastic sheeting will be removed, and work will commence to the next section of the building.

3.2.3 Sorting of Debris Wastes

After all materials are removed from areas where there is a potential asbestos hazard as described above, the remaining work in the building can be performed by non- asbestos trained workers. Cabrera will then begin the process of moving and sorting the remaining debris into different categories:

1) Drums
2) Large, non-porous debris with smooth surfaces to be surveyed and released
3) Miscellaneous soil-like material/debris / trash

There will be separate staging areas set up in a designated part of Building 3H (i.e., to be determined at a later time depending on where asbestos abatement is required). Four "bins" will be established. A set of concrete "Jersey barriers" will be used to separate each area. A detailed description of the different materials to be staged is described below.

If additional discrete pieces of radioactive material are found during the moving and sorting of the debris piles, the pieces should be segregated, packaged and secured; Knolls Atomic Power Laboratory should be notified. Knolls personnel will inspect the material on-site and will coordinate with GE/Cabrera on a course of action.

3.2.3.1 Drums

There are several drums of known and unknown contents inside the building. Some of the drums and their contents are labeled, and several are not. Several of these drums are rusted and contain holes. Several of the drums appear to be empty. The drums were brought and stored in the building after active UNC operations were completed. Therefore, it is assumed that none of these drums contain radioactive materials. However, there is a potential that the exterior surfaces of the drums may have been radiologically contaminated since being inside the building. The drums will be moved staged together in one bin. The exterior surfaces of each of the drums will be surveyed for radioactivity. If the drums meet release criteria (Regulatory Guide 1.86 limits for uranium [USNRC, 1974]), then the drums will be moved to another area of the building (to be determined with the concurrence of the Property Owner) and managed/removed by the Property Owner. If a drum does not meet release criteria, then attempts will be made to decontaminate the outer surface of the drum via wiping and/or cleaning the surface. If the drums is known to contain solid/and or liquid, and there are no pre-existing holes in the drum, then all efforts will be made to not breach the intact drum during this decontamination effort.

If a drum cannot be moved without spilling its contents due to its rusted condition, then Cabrera will notify UNC. A specialty hazardous waste subcontractor will be notified to manage the drum in accordance with 29 CFR 1910.120 (HAZWOPER). This procedure is provided with this plan as Appendix D. The subcontractor will most likely overpack the drum and move it to the appropriate staging area for further disposition/surveys.

3.2.3.2 Large Debris to be Surveyed Prior to Release

Debris inside the building needs to be moved in order to facilitate characterization surveys of the remainder of the building. This debris (including, but not limited to, office furniture, equipment, large containers, and structural steel) that is not otherwise mixed with ACM has been moved into the building since UNC's active operations. If there is residual radioactivity present on these items, then it is likely to be only on the outer surfaces of the debris. Any debris that can be decontaminated (i.e., consisting of non-porous materials such as metal, rubber, plastic that can be wiped clean) will be segregated and staged into a designated debris bin. The exterior surfaces of these items will be surveyed for radioactivity. If the debris meet release criteria (Regulatory Guide 1.86 limits for uranium), then it will be moved to another area of the building (to be determined with the concurrence of the Property Owner) and managed/removed by the Property Owner. If a piece of debris does not meet release criteria, then a second attempt will be made to decontaminate the contaminated surface(s) of the item via wiping and/or cleaning. If any of this debris cannot be decontaminated successfully after two attempts, the debris will be moved to a bin containing other radiological wastes, sized, and loaded into lined IMCs.

3.2.3.3 Miscellaneous Soil-like Material and Debris / Trash

All other debris (i.e., small items, soil-like material or items consisting of porous materials such as wood, cloth, paper, etc.) will be segregated, added to the radiological waste stream, and either staged in a designated bin inside the building or directly loaded into lined IMCs.

3.2.4 Processed Waste Sampling Profile and Disposal Facility Acceptance

Each waste stream will be characterized as described in Section 3.2 and the waste will be confirmed to meet the USEI WAC. Characterization will be performed, as specified in Section 3.1 of this *WMP*, to:

- Identify and quantify radioactivity in waste to verify compliance with the USEI WAC.
- Determine the non-radiological hazardous characteristics, if any, of the waste to guide processing of the material, if necessary, and verify the waste meets the USEI WAC.
- Address each of the requirements necessary to complete the waste profile for USEI.

3.2.5 Waste Packaging

Radiological wastes will be transported to EnergySolutions in IMCs. Each container will comply with the specifications for a strong tight container and IP-1 packaging listed in 49 CFR Part 173. IMCs each have a maximum load capacity of approximately 25 CY and will have rolling aluminum lids.

Transport vehicles and waste containers offered for transportation will be radiologically surveyed for release from the site in accordance with DOT criteria in 49 CFR 173, Subpart I, *Class 7 (Radioactive) Materials*. The waste container internal surfaces are not intended to be received as "rad-clean" and are not subject to these criteria, although the internal surfaces will be surveyed to document their incoming radiological condition. These criteria include radiation level (less than 0.5 millirem per hour dose rate at any point on the external surface of the package) and contamination (less than 220 disintegrations per minute per 100 square centimeters [dpm/100 cm^2] and 2,200 dpm/100 cm^2 for removable alpha and beta activity, respectively) limits. These are the most restrictive DOT regulations for a radioactive material shipment, which apply to shipping excepted packages for limited quantity of radioactive material. Each package must be designed and prepared such that, under conditions normally incident to transportation, the specified radiation levels are not exceeded. The levels of removable contamination on the external surfaces of the packages and vehicles will be determined by smearing an area of 300 cm^2 of the surface and converting the measured results to the limits listed above, and must also be kept ALARA.Preparation of each IMC for shipment will include:

- Radiological dose rate and removal activity surveys of each empty IMC prior to loading on-site.
- Documented physical inspection of each IMC to verify there are no holes or damage, gaskets are present and intact and general appearance is satisfactory.
- Verify the IMC is empty with no residual soil, material or other debris.
- Verify permanent markings are readily readable, including tare and load weight.
- Remove or obscure any non-permanent markings or unnecessary placards.
- Install a waste liner in preparation for waste loading.

IMC Loading:

- Debris wastes shall be sized, if necessary, to meet EnergySolutions's WAC.
- Waste packages will be loaded in a way to minimize void spaces and conserve space in each IMC.
- After the IMC is filled, the lid will be shut and fastened using the closure devices, and the rear door closures and chains will be tightened, if necessary. The IMC will also be completely shut and secured at the end of each work day during remedial activities.

IMC Preparation for Shipment:

- Radiological surveys will be completed and documented to verify DOT limits (listed above) are met.
- DOT required markings, labels and placards will be applied as necessary.
- Shipping papers will be completed (Non-hazardous bill of lading for radiological wastes, RCRA Uniform Hazardous Waste Manifest for hazardous wastes).

3.2.6 Waste Transportation

IMCs will be transported using the most cost effective option based on the total quantity (i.e., rail or truck) to EnergySolutions utilizing Greenfield Logistics as the waste transportation subcontractor. The Waste Broker will ensure that each waste shipment is accompanied by properly completed shipping documents and use appropriate documents as required by Federal, State, and local laws and regulations. Such forms may include a non-hazardous waste manifest, RCRA Uniform Hazardous Waste Manifest (if required based on waste characterization results), and may include a Land Disposal Restriction Notification, examples of which are included in Appendix E. Final shipping documents will be prepared by Waste Broker, or qualified designee. All completed documents for non-hazardous radiological wastes requiring shipper's and waste certifications will be signed by the Cabrera waste broker prior to release of each shipment.

Prior to shipment Cabrera's Waste Broker, or qualified designee, will:

- Verify all waste packaging records are complete;
- Conduct and document a visual inspection of the conveyance and ensure any discrepancies are corrected;
- Verify the conveyance is properly marked, labeled and placarded, as applicable;
- Review all paperwork to ensure legibility;
- Verify that the transporter's representative understands all special instructions such as maintenance and prior notification requirements;
- Ensure that the drivers for Greenfield Logistics are endorsed to transport hazardous waste (if hazardous waste is generated);
- Verify the transporter's representative and Cabrera have signed all required forms; and
- Make any additional pre-shipment notifications. This might include pre-notifications required by individual states or corrections to information already provided in previous notifications. Forward copies of the shipping papers to the conveyance recipient, as applicable.

3.2.6.1 Post Shipment Requirements

Following shipment, the Site Manager and waste broker will:

- Verify all records are complete for the shipment and copies filed at the Site;
- Arrange for regularly scheduled in-transit updates from Greenfield until the conveyance reaches the disposal facility;
- Verify receipt notification is obtained once the shipment arrives at EnergySolutions and shipment records updated, as necessary;
- Resolve any shipment discrepancies that may be identified as a result of inspections of the conveyance and/or package waste at EnergySolutions;

- Provide shipping papers and receipts to UNC;
- Receive the Disposal Certification Form from EnergySolutions, compare to the shipment records for accuracy and attach to the shipment file for inclusion into the project report.

3.2.7 Waste Characterization Samples

Waste characterization sampling will be conducted during remedial activities. This sampling will support the determination of the applicable DOT and waste classifications.

Composite samples of dirt and smaller pieces of debris will be collected and counted using an on-site gamma spectroscopy detector to determine the total uranium content. If the wastes are found to contain HEU, then the total activity will be tracked on Cabrera's NRC license and the on-site MBA inventory until the waste is shipped off-site, at which point it will be transferred to EnergySolutions's inventory. All materials containing HEU will be handled in accordance with the approved *Nuclear Material Control and Accountability Plan* (Cabrera, 2010).

At least one sample of dirt/dust/debris will be collected and sent off-site for a full waste characterization analysis via the Toxicity Characteristic Leaching Procedure (TCLP) (EPA Method SW846) to ensure the waste meets EnergySolutions's WAC.

Sampling and chain of custody will be performed in accordance with *OP-005, Volumetric and Material Sampling Within Radiological Control Areas, Rev. 2*, and *OP-008, Chain of Custody, Rev.1*.

3.2.8 Quality Assurance/Quality Control

Quality control criteria established for instrumentation and daily performance checks will be conducted prior to using instrumentation on a daily basis. QC criteria will include establishing a mean source count rate using a radioactive source in a reproducible geometry, standard deviation and multiples of the standard deviation (two and three times the standard deviation of the mean) to define control limits. QC performance checks will include analysis of the check source in the same counting geometry and comparison of the result with the QC criteria. Typically, the daily performance QC checks fall within the mean plus two standard deviations which demonstrate acceptable performance. Whenever a daily performance check falls outside the mean plus two standard deviations but within the mean plus three standard deviations the result will be flagged as "questionable." Measurements following a questionable QC measurement will be reviewed to ensure a trend adverse to performance is not occurring. Daily performance checks that fall outside the mean plus three standard deviations will result in an instrument being removed from service. Implementations of QA and QC measures for this work plan are described in *OP-021, Alpha-Beta Counting Instrumentation, Rev. 1*, and *OP-429, Gamma Spectroscopy Operations, Rev. 5* (see Appendix C).

3.2.9 Demobilization

Cabrera will demobilize from the Site at the conclusion of remediation and waste transport activities. Subcontractor personnel on site for asbestos abatement will be demobilized immediately following completion of abatement and radiological release of their equipment. All equipment coming into contact with contaminated waste will be decontaminated and radiological surveys performed for unrestricted release prior to demobilization in accordance with *OP-004 Unconditional Release of Materials from Radiological Control Area, Rev. 2* (Appendix C).

4.0 REFERENCES

Cabrera, 2010 Nuclear Material Control and Accountability Plan. Site Decommissioning Former UNC Manufacturing Facility, New Haven, Connecticut. Cabrera Services Inc. March, 2010.

Cabrera, 2014a Accident Prevention Plan. Site Decommissioning Former UNC Manufacturing Facility, New Haven, Connecticut. Cabrera Services Inc. 2014.

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MARSSIM, 2000 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575, EPA 402-R-97-016, DOE/EH-0624, Revision 1. U.S. Department of Defense, U.S. Department of Energy, U.S. Environmental Protection Agency & U.S. Nuclear Regulatory Commission. August, 2000.

USNRC, 1973 Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted use or Termination of Licenses for Byproduct, Source or Special Nuclear Material." U.S. Nuclear Regulatory Commission. May 3, 1973.

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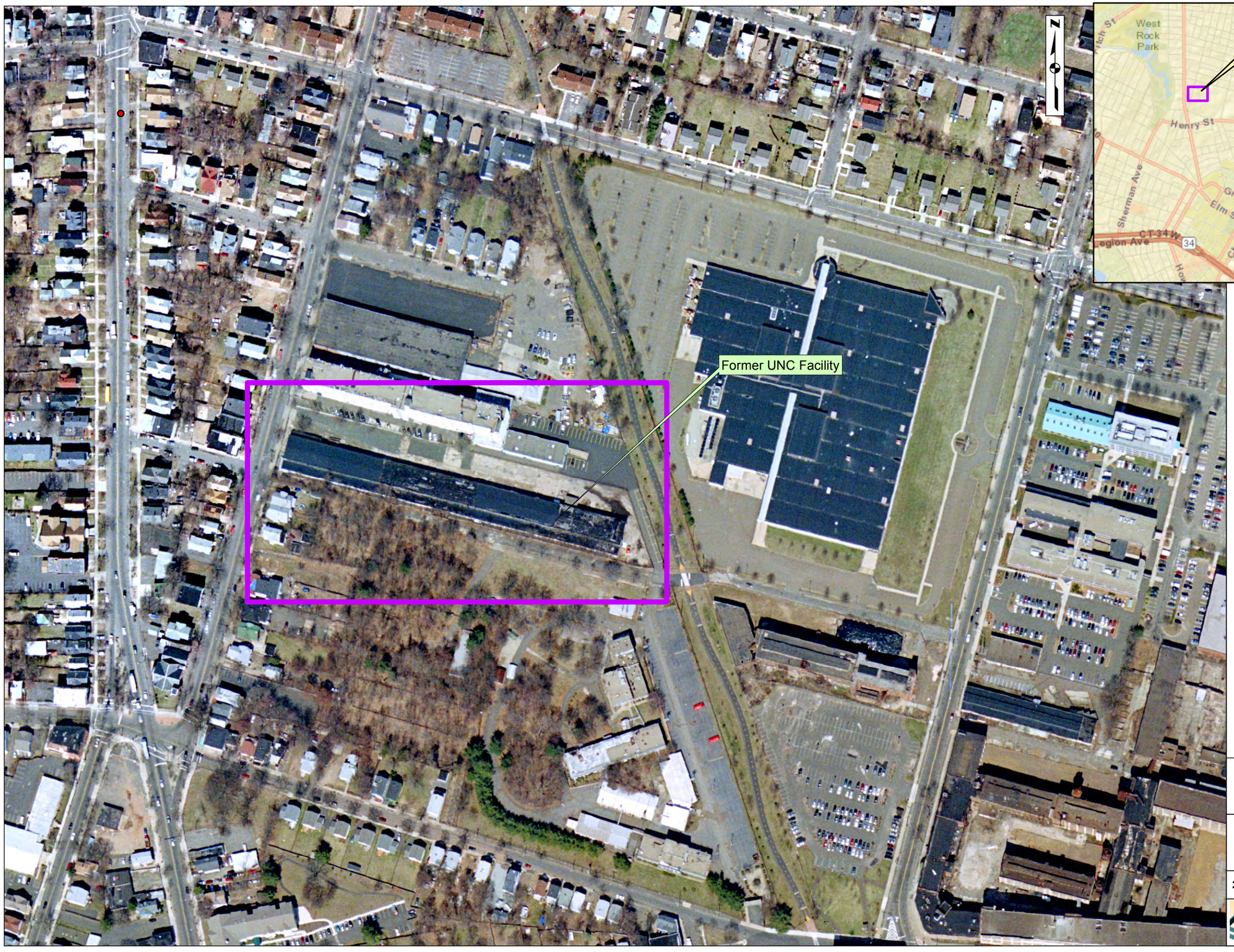
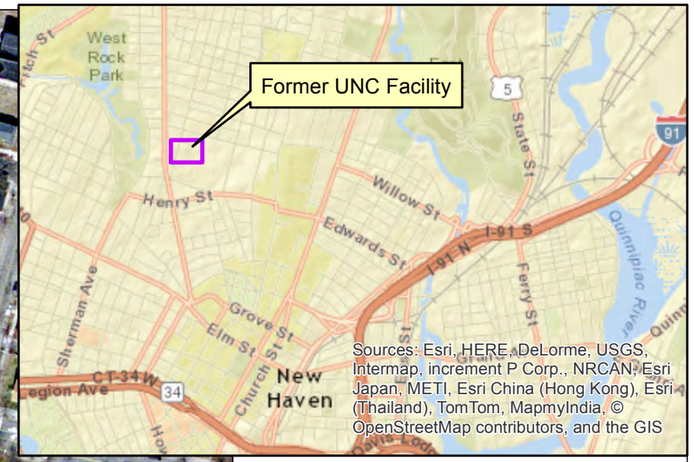
USNRC, 1981 Branch Technical Position, Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations. U.S. Nuclear Regulatory Commission. October, 1981.

USNRC, 1996 USNRC, Inspection Report. Former United Nuclear Corporation (UNC), Buildings 3H and 6H, 71 Shelton Avenue, New Haven, Connecticut. U.S. Nuclear Regulatory Commission. July 26, 1996.

APPENDIX A
FIGURES





Location of Connecticut

Location of Former UNC Facility

0 100 200 400

Feet

SITE LOCATION

FORMER UNC FACILITY
NEW HAVEN, CONNECTICUT

2/2016	SMO	PROJECT NO. 10-1007.00	FIGURE 1
	Cabrera Services Baltimore, MD		

ACM Abatement Required

ACM Abatement Likely Not Needed

Buildings

Existing Building

Demolished

0 40 80 160

Feet

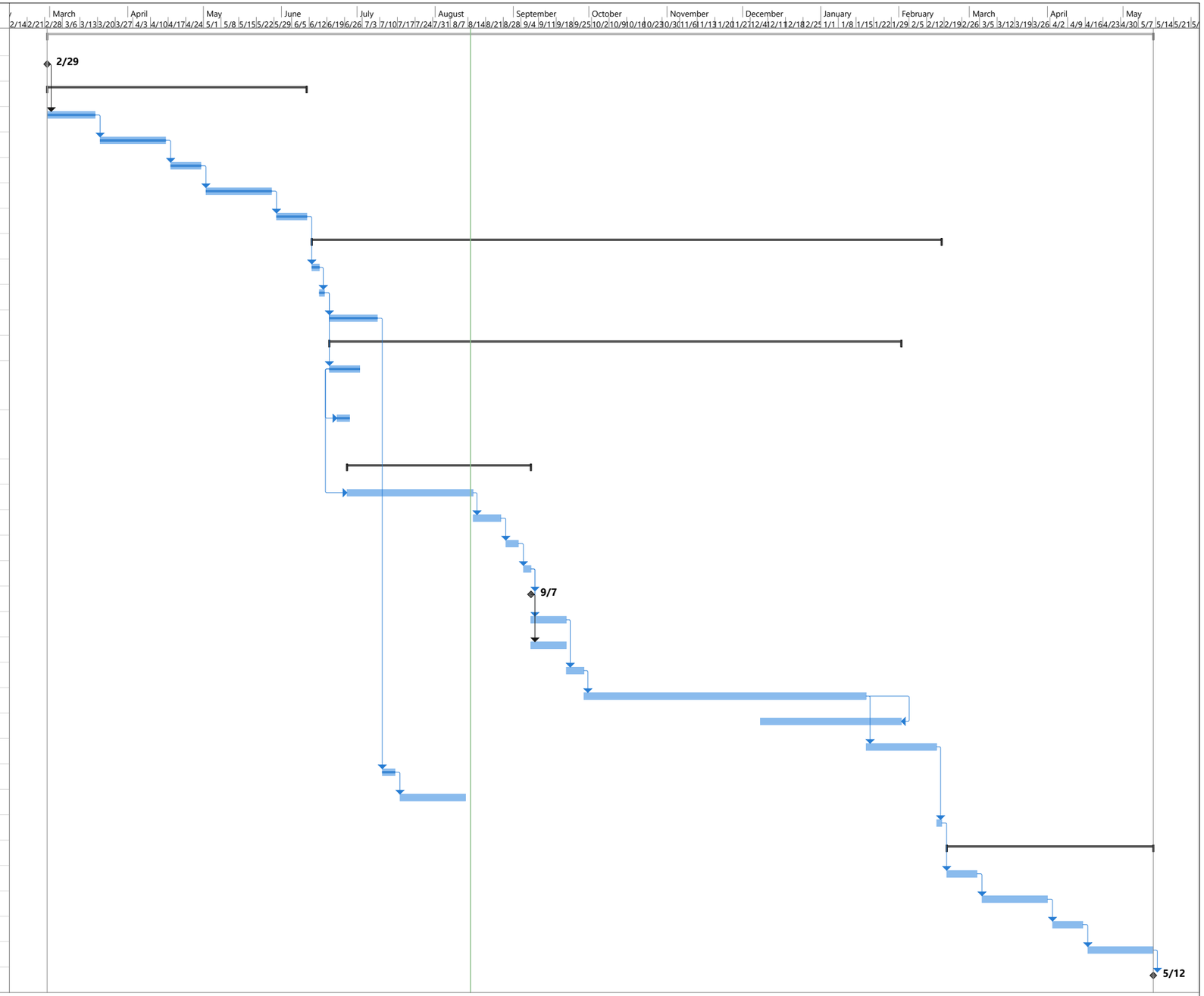
ACM ABATEMENT

FORMER UNC FACILITY
NEW HAVEN, CONNECTICUT

7/2016	SMO	PROJECT NO.	FIGURE
	Cabrera Services Baltimore, MD		

APPENDIX B
PROJECT SCHEDULE

ID	WBS	Task Name	% Complete	Duration	Start	Finish
0		**UNCNH-Debris Removal**	**27%**	**315 days**	**Mon 2/29/16**	**Fri 5/12/17**
1	**0**	**Notice to Proceed**	100%	0 days	Mon 2/29/16	Mon 2/29/16
2	**1**	**Supplemental Survey Plan**	**100%**	**75 days**	**Mon 2/29/16**	**Fri 6/10/16**
3	1.1	Prep and Submittal	100%	15 days	Mon 2/29/16	Fri 3/18/16
4	1.2	NRC Review	100%	20 days	Mon 3/21/16	Fri 4/15/16
5	1.3	Incorporate Comments and Submit Revised Plan	100%	10 days	Mon 4/18/16	Fri 4/29/16
6	1.4	NRC Review and Acceptance	100%	20 days	Mon 5/2/16	Fri 5/27/16
7	1.5	NRC License Notification	100%	10 days	Mon 5/30/16	Fri 6/10/16
8	**2**	**Survey Field Work**	**14%**	**180 days**	**Mon 6/13/16**	**Fri 2/17/17**
9	2.1	Mobilization and Set-up	100%	3 days	Mon 6/13/16	Wed 6/15/16
10	2.2	Building 3H Ductwork Survey	100%	2 days	Thu 6/16/16	Fri 6/17/16
11	2.3	6H Accessible Floor Survey	100%	15 days	Mon 6/20/16	Fri 7/8/16
12	**2.4**	**Material and Debris Removal from 3H/6H**	**6%**	**163 days**	**Mon 6/20/16**	**Wed 2/1/17**
13	2.4.1	Collect, analyze, package and ship metal fragments to KAPL	100%	10 days	Mon 6/20/16	Fri 7/1/16
14	2.4.2	Scan existing and former exits from 3H/6H and site property	100%	3 days	Thu 6/23/16	Mon 6/27/16
15	**2.4.3**	**Material and Debris Removal Work Plan**	**0%**	**53 days**	**Mon 6/27/16**	**Wed 9/7/16**
16	2.4.3.1	Prepare and submit Work Plan	0%	36 days	Mon 6/27/16	Mon 8/15/16
17	2.4.3.2	NRC Review	0%	9 days	Tue 8/16/16	Fri 8/26/16
18	2.4.3.3	Prepare and submit Final Work Plan	0%	5 days	Mon 8/29/16	Fri 9/2/16
19	2.4.3.4	NRC Review and Acceptance	0%	3 days	Mon 9/5/16	Wed 9/7/16
20	2.4.4	Notice to Proceed with Removal Work	0%	0 days	Wed 9/7/16	Wed 9/7/16
21	2.4.5	Cabrera NRC License Notification	0%	10 days	Thu 9/8/16	Wed 9/21/16
22	2.4.6	ACM Abatement Notification to CDPH	0%	10 days	Thu 9/8/16	Wed 9/21/16
23	2.4.7	Mobilization and Set-up	0%	5 days	Thu 9/22/16	Wed 9/28/16
24	2.4.8	Material and Debris Removal Work	0%	80 days	Thu 9/29/16	Wed 1/18/17
25	2.4.9	Transportation and Disposal of IMCs	0%	40 days	Thu 12/8/16	Wed 2/1/17
26	**2.5**	**3H/Remainder of 6H Floor Surveys**	0%	20 days	Thu 1/19/17	Wed 2/15/17
27	**2.6**	**Former 9H, 10H, 11H Soil boring/sampling**	100%	5 days	Mon 7/11/16	Fri 7/15/16
28	**2.7**	**Off-site Characterization Sample Lab Analysis**	0%	20 days	Mon 7/18/16	Fri 8/12/16
29	**2.8**	**Demobilization**	0%	2 days	Thu 2/16/17	Fri 2/17/17
30	**3**	**Survey Report**	**0%**	**60 days**	**Mon 2/20/17**	**Fri 5/12/17**
31	3.1	Prep and Submittal	0%	10 days	Mon 2/20/17	Fri 3/3/17
32	3.2	NRC Review	0%	20 days	Mon 3/6/17	Fri 3/31/17
33	3.3	Incorporate Comments and Submit Revised Report	0%	10 days	Mon 4/3/17	Fri 4/14/17
34	3.4	NRC Review and Acceptance	0%	20 days	Mon 4/17/17	Fri 5/12/17
35		**Survey and Reporting Complete**	0%	0 days	Fri 5/12/17	Fri 5/12/17



Project: UNCNH-Debris Removal
Date: Mon 8/15/16

Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress

APPENDIX C
CABRERA STANDARD OPERATING PROCEDURES

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

RADIATION SAFETY PROCEDURE

FOR

ALARA

AP-005

Revision 2.0

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

This procedure provides the requirements and methods Cabrera Services Inc. (CABRERA) personnel will utilize for conducting As Low As Reasonably Achievable (ALARA) reviews and briefings.

2.0 APPLICABILITY

This procedure applies to formal ALARA reviews and briefings conducted by the Project Radiation Safety Committee (RSC), which includes the Radiation Safety Officer (RSO). Records created from the operation of this procedure are used by project radiological safety personnel to document work evolution, and maintain doses ALARA. ALARA reviews are initiated based on dose trigger levels.

3.0 DEFINITIONS

As Low As Reasonably Achievable (ALARA) – Process to make use of every reasonable effort to maintain exposures to radiation as far below the dose limits, as is practical. Reducing radiation exposures at a site to ALARA levels strikes a balance between what is possible through additional planning and management, remediation, and the use of additional resources to achieve a lower collective dose level.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

There are no special precautions associated with this procedure.

4.2 Limitations

There are no special limitations associated with this procedure.

4.3 Requirements

4.3.1 Work activities performed, under this procedure, will use the most current radiological data for the project and will be in accordance with the Radiation Work Permit (RWP), Health and Safety Program (HASP), and Radiation Safety Program (RSP).

4.3.2 Documents created from use of this procedure will be maintained in accordance with OP-187, *Records Management*.

4.3.3 Radiation dose histories for site workers will be obtained prior to the start of the project, as appropriate.

5.0 EQUIPMENT

There is no equipment associated with this procedure.

6.0 RESPONSIBILITIES

6.1 Radiation Safety Committee (RSC) – The RSC is responsible for high level review, evaluation, and action on ALARA issues that affect the Radiation Safety Program.

6.2 Project Manager (PM) – The PM is responsible for the radiological safety of all personnel onsite; and ensuring that, if they work in radiologically controlled areas, that they know and understand with this procedure, adequately trained in its use, and have readily available access to a copy.

6.3 Radiation Safety Officer (RSO) – The RSO will ensure that personnel who work with radioactive material are trained, and have an adequate understanding of ALARA principles and the use of this procedure. The RSO is also responsible for reviewing and approving ALARA documents, as well as conducting, reviewing and/or approving ALARA reviews and briefings described in this procedure.

6.4 Site Radiation Safety Lead (SRSL) – The SRSL acts as the RSO's duly authorized representative for radiological issues when the RSO and NRC-listed License Authorized Users are not onsite. When on site, the SRSL will ensure the requirements established in this procedure are implemented.

6.5 Radiation Protection Technician (RPT) – The RPT is responsible for the control of radioactive material, coverage of radiation workers, general safety protection and counseling workers to maintain exposures ALARA. The RPT is responsible for fully understanding and complying with this procedure.

7.0 PROCEDURE

7.1 This procedure sets the minimum standards for performance of formal ALARA reviews and briefings. It does not prohibit the performance of any reviews by the client's Radiation Protection Department that are in addition to those established by this procedure.

7.1.1 The RSO will discuss with the PM, if necessary, the dose reduction techniques pertinent to project tasks that do not meet the criteria for formal reviews, as set by this procedure.

7.1.2 All personnel involved in the project are expected to participate in and support efforts to perform ALARA related activities. They will discuss any ALARA concerns with the PM or RSO, as appropriate.

7.1.3 Dose rate reduction methods will be identified and recorded prior to and during job performance.

7.2 Conducting ALARA Reviews and Briefings

7.2.1 Documented ALARA reviews and briefings for work conditions listed in Exhibit 1 will be in accordance with their associated risk factor listed in the same table.

Exhibit 1: Formal ALARA Job Review and Briefing Requirements

<table>
<tr><th>WORK CONDITIONS</th><th>RISK FACTOR*</th><th>REVIEW CONDUCTED BY</th><th>REVIEW APPROVED BY</th><th>BRIEFING CONDUCTED BY</th></tr>
<tr><td rowspan="3">1. Any individual dose is expected to exceed 25 millirem (mrem).
2. The collective dose for the job exceeds 0.1 person rem.
3. Airborne exposures exceed 12 Derived Air Concentration (DAC)-hours per week for any single individual.
4. General area dose rates exceed 1 millirem per hour (mrem/hr).
5. Contamination levels exceed 100 times the values in “Surface Activity Guidelines“ (Attachment A)</td><td>1-5X</td><td>RPT/SRSL</td><td>RSO/ RSC</td><td>RPT/SRSL</td></tr>
<tr><td>5-10X</td><td>RSO/RSC</td><td>RSO/RSC</td><td>RSO</td></tr>
<tr><td>>10X</td><td>RSO/RSC</td><td>RSO/RSC</td><td>RSO</td></tr>
<tr><td>6. Use of supplemental engineering controls (HEPA filter systems, glove bags, tents, and other similar devices) and respiratory protection to reduce potential internal exposures.
7. Installation, removal, or modification or temporary shielding.</td><td colspan="4">These work conditions have non-readily determined risk factors associated with them, and will be reviewed and approved by the RSO or RSC in all instances.</td></tr>
<tr><td colspan="5">* The risk factor is multiplied by the expected dose to decide who will conduct the reviews, approvals and briefings. (e.g., a risk factor of 5 multiplied by work condition 4’s dose of 1 mrem/hr will determine that the RSO/RSC will conduct and approve the review, and the briefing will be conducted by the RSO).</td></tr>
</table>

7.2.2 A pre-job review will include the RWP, Project ALARA Review Form (Attachment B), survey records, previous job performance records, and technical work control documents, as appropriate.

7.2.3 The appropriate designee, listed in Exhibit 1, will conduct job reviews and briefings. Periodic ALARA job-in-progress reviews will be conducted if work conditions extend beyond one week. The PM will provide any pertinent information regarding ALARA controls for the project.

7.2.4 Pre-job and job-in-progress briefings will be performed and documented using the attached “ALARA Briefing Record” (Attachment C) and the “ALARA Briefing Attendance Record” in Attachment D.

7.2.5 Attendance at post-job reviews will include, at a minimum, all personnel that were involved in ensuring radiation safety at the jobsite. The radiation safety individual that conducted the pre-job review will conduct the post-job review, if practical.

7.3 Review and Briefing Recordkeeping

7.3.1 All reviews will be documented on the “Project ALARA Review Form” found in Attachment B.

7.3.2 If initial person-rem estimates need to be revised, then they will be recorded in the final section of the Project ALARA Review Form; and, the explanations for all revisions will be documented with annotated sheets to the form.

7.3.3 If additional ALARA requirements are identified during the pre-job or job-in-progress briefings, then they will be added to the Special Instructions section of the RWP.

7.3.4 Any additional information obtained from task workers, or personnel ensuring radiation safety of the project, will be annotated in the Corrective Action section of the form.

7.3.5 During the performance of the job, any information collected that could reduce collective or individual dose rates, for future work, will be documented on pages attached to the form.

7.3.6 Original copies of all documentation generated from the use of this procedure will be forwarded to the RSO for processing, including arrangement and filing. They are used in the RSP to document contamination levels of work areas and materials onsite. Selected items may be included in the Radiological Conditions Awareness Log or Radiological Conditions Awareness Report (see AP-003, *Radiological Conditions Awareness Report)*, as appropriate.

8.0 REFERENCES

- Title 10, Code of Federal Regulations, Part 20, *Standards for Protection Against Radiation*.
- Health and Safety Program, Cabrera Services Inc., Manual
- Radiation Safety Program, Cabrera Services Inc., Manual

- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure

9.0 REQUIRED RECORDS

- Procedure training records
- Dose rate reduction methods
- Surface Activity Guidelines
- Project ALARA Review Form
- ALARA Briefing Record
- ALARA Briefing Attendance Record

10.0 ATTACHMENTS

- Attachment A – Surface Activity Guidelines
- Attachment B – Project ALARA Review Form
- Attachment C – ALARA Briefing Record
- Attachment D – ALARA Briefing Attendance Record

Attachment A

Surface Activity Guidelines

Surface Activity Guidelines

ALLOWABLE TOTAL RESIDUAL SURFACE ACTIVITY (DPM/100CM^2)(1)			
RADIONUCLIDES(2)	AVERAGE(3,4)	MAXIMUM(4,5)	REMOVABLE(6)
Transuranics, ^{125}I, ^{129}I, ^{227}Ac, ^{226}Ra, ^{228}Ra, ^{228}Th, ^{230}Th, ^{231}Pa	100	300	20
Th-natural, ^{90}Sr, ^{126}I, ^{131}I, ^{223}Ra, ^{224}Ra, ^{232}U, ^{232}Th	1,000	3,000	200
U-natural, ^{235}U, ^{238}U, and associated decay products, alpha emitters	5,000 α	15,000 α	1,000 α
Beta-gamma emitters(7) (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above	5,000 β γ	15,000 β γ	1,000 β γ

Notes:

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

(2) Where surface contamination by both alpha and beta-gamma emitting radionuclides exists, the limits established for alpha and beta-gamma emitting radionuclides should apply independently.

(3) Measurements of average contamination should not be averaged over an area of more than one m^2. For objects of less surface area, the average should be derived for each object.

(4) The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr, respectively, at 1 m.

(5) The maximum contamination level applies to an area of not more than 100 cm^2.

(6) The amount of removable material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping media with an appropriate instrument of known efficiency. When removable contamination on objects of surface area of less than 100 cm^2 is determined, the activity per unit area should be based on the actual area, and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if detector scan surveys indicate that the total residual surface contamination levels are within the limits for removable contamination.

(7) This category of radionuclides includes mixed fission products, including ^{90}Sr, which has been separated from the other fission products, or mixtures where the ^{90}Sr has been enriched.

Attachment B

Project ALARA Review Form

Project ALARA Review Form

RWP #		**Revision**		**Task Location**				
Pre-Job Review Date				**Conducted by**				
In Progress/Post-Job Review Date				**Conducted by**				
ALARA Goals:	**person-rem**		**DDE**		**CEDE**		**TEDE**	

		REVIEW CRITERIA		**ACTION**	**COMMENTS**
PRE-JOB REVIEW	1.	Are technical work documents that accurately define the work available?		Yes No N/A	
	2.	Has the procedure been verified through walk-downs or prior performance?		Yes No N/A	
	3.	Do procedures/work checklists/documents have approved hold points?		Yes No N/A	
	4.	Are there specific points in the work evolution at which radiological conditions are subject to change? If yes, are these addressed as hold points in work documents?		Yes No N/A	
	5.	Has the work force performed this previously?		Yes No N/A	
	6.	Is specific training required prior to job performance?		Yes No N/A	

Project ALARA Review Form (Continued)

PRE-JOB REVIEW	7.	Are photographs, videos, and or drawings of the areas(s) to be worked available?		Yes	
				No	
				N/A	
	8.	Has the size of the work crew needed to perform the job been evaluated?		Yes	
				No	
				N/A	
	9.	Have all identified support groups been notified of scheduled work and briefing requirements?		Yes	
				No	
				N/A	
	10.	Have the primary sources of exposure been identified?		Yes	
				No	
				N/A	
	11.	Any significant increase in airborne radioactive materials likely as a result of the work being performed?		Yes	
				No	
				N/A	
	12.	Have engineering controls including HEPA filtration devices been selected to reduce the potential for airborne releases?		Yes	
				No	
				N/A	
	13.	If the release of airborne radioactive materials cannot be eliminated through the use of engineering and process controls has the use of respirators been evaluated in accordance with HASP and TEDE ALARA principles?		Yes	
				No	
				N/A	
	14.	Can work be moved to a lower dose rate area?		Yes	
				No	
				N/A	
	15.	Have ALARA low dose rate areas been identified and their use explained to the workers?		Yes	
				No	
				N/A	

Project ALARA Review Form (Continued)

PRE-JOB REVIEW	16.	Are stay times appropriate for reduction of individual doses?		Yes	
				No	
				N/A	
	17.	Have travel routes to and from work areas been selected and discussed with workers?		Yes	
				No	
				N/A	
	18.	Can remote tools and/or robotics be utilized?		Yes	
				No	
				N/A	
	19.	Is any special equipment or procedural restriction required to ensure worker safety during work performance including lockout/tagout requirements?		Yes	
				No	
				N/A	
	20.	Is heat or cold stress a concern? Have stay times been evaluated for heat or cold stress considerations?		Yes	
				No	
				N/A	
	21.	Does the work involve the use or generation of hazardous materials? Can this result in additional collective dose?		Yes	
				No	
				N/A	
	22.	Will the work involve waste being generated? Is mixed waste a concern?		Yes	
				No	
				N/A	
	23.	Has the handling and disposal of waste products been determined?		Yes	
				No	
				N/A	
	24.	Will liquids be generated, collected, and/or routed to drains? Have necessary permits been obtained?		Yes	
				No	
				N/A	

Project ALARA Review Form (Continued)

PRE-JOB REVIEW	25.	Are whole-body thermoluminescent dosimeters (TLDs) sufficient to monitor potential exposures expected to be encountered?		Yes	
				No	
				N/A	
	26.	Is multi-badging required?		Yes	
				No	
				N/A	
	27.	Is extremity badging required?		Yes	
				No	
				N/A	
	28.	Does the work involve any criticality concerns? Have controls been identified?		Yes	
				No	
				N/A	
	29.	Are Alarming Radiation Monitors (ARMs) or Continuous Air Monitors (CAMs) going to be used during this work evolution?		Yes	
				No	
				N/A	
	30.	Is a bioassay program required during or following the completion of work?		Yes	
				No	
				N/A	
	31.	Are any non-routine items of protective clothing required (face shields, heavy rubber gloves, bubble hoods, etc.)?		Yes	
				No	
				N/A	
	32.	Will on-the-job photographs or videos be made to record job conditions or step completion?		Yes	
				No	
				N/A	
	33.	Are administrative radiation control limits in place for workers as required?		Yes	
				No	
				N/A	

Project ALARA Review Form (Continued)

PRE-JOB REVIEW	34.	Is work being performed as required by technical work documents and the RWP(s)?		Yes	
				No	
				N/A	
	35.	Are workers knowledgeable of radiological conditions and protective equipment requirements in the work area?		Yes	
				No	
				N/A	
	36.	Are workers aware of their exposure to date?		Yes	
				No	
				N/A	
	37.	Are tools and equipment available at the job site adequate for the tasks to be performed?		Yes	
				No	
				N/A	

REVIEW CRITERIA			ACTION		COMMENTS
IN PROGRESS/POST-JOB REVIEW	1.	Are tagout/lockout procedures being followed?		Yes	
				No	
				N/A	
	2.	Were any unanticipated radiological conditions encountered?		Yes	
				No	
				N/A	
	3.	Can additional dose reduction measures be applied to further reduce worker doses?		Yes	
				No	
				N/A	
	4.	Is dosimetry being worn and stored properly?		Yes	
				No	
				N/A	
	5.	Were equipment needs and the materials needed for the job identified in the procedure?		Yes	
				No	
				N/A	

Project ALARA Review Form (Continued)

IN PROGRESS/POST-JOB REVIEW	6.	Were prerequisite activities completed prior to the start of the job?		Yes	
				No	
				N/A	
	7.	Were support groups present when required for the job evolution?		Yes	
				No	
				N/A	
	8.	Was job-specific training completed for this job? Was it adequate for the job?		Yes	
				No	
				N/A	
	9.	Were any unplanned or unanticipated conditions encountered? If yes, explain.		Yes	
				No	
				N/A	
	10.	Were estimated manpower requirements exceeded? If yes, explain.		Yes	
				No	
				N/A	
	11.	Were low dose rate areas and staging used? If yes, were they effective?		Yes	
				No	
				N/A	
	12.	Were required services available (electrical, ventilation, lights, etc.)?		Yes	
				No	
				N/A	
	13.	Was temporary shielding used? Was it adequate?		Yes	
				No	
				N/A	
	14.	Were engineering controls used to reduce potential for airborne radioactive materials? Were they effective?		Yes	
				No	
				N/A	

Project ALARA Review Form (Continued)

IN PROGRESS/POST-JOB REVIEW	15.	Were contamination control practices followed? Were they effective?		Yes	
				No	
				N/A	
	16.	Were respirators or other airborne protective equipment utilized? Did they impact job performance?		Yes	
				No	
				N/A	
	17.	Were procedure changes needed during work evolutions to accommodate lessons learned?		Yes	
				No	
				N/A	
	18.	Were additional radiological hold points needed during work evolutions?		Yes	
				No	
				N/A	
	19.	Are equipment or process changes needed to help reduce exposures for the next job performance? If yes, explain.		Yes	
				No	
				N/A	
	20.	Were person-rem goals exceeded? If yes, explain.		Yes	
				No	
				N/A	
	21.	Could activities or scheduled plan of activities been done differently to reduce exposures the next time this job is performed? If yes, explain.		Yes	
				No	
				N/A	

Additional comments may be annotated on pages attached to this form and referenced to the criteria number in the ALARA review

Corrective actions recommended or taken (specify actions required by RSO, or RSC) _____

_____

_____

_____

_____

ALARA Estimates:	**DDE**		**CEDE**		**TEDE**
Original person rem goal	_____	+	_____	=	_____
Final person rem values	_____	+	_____	=	_____
Review performed by	_____ (print and sign)				_____ (date)
RSO/RSC approval	_____ (print and sign)				_____ (date)
PM approval	_____ (print and sign)				_____ (date)

Attachment C

ALARA Briefing Record

ALARA Briefing Record

RWP#: _____ Revision: _____ Start Date: _____

Task Description: _____

_____

_____

_____

_____

Radiation Safety: _____ (Print/Sign)

Project Manager: _____ (Print/Sign)

Site Radiation Safety Lead: _____ (Print/Sign)

Attachment D

ALARA Briefing Attendance Record

ALARA Briefing Attendance Record

DATE	NAME		SSN/ID#	BRIEFING SUBJECT
	PRINT	SIGN		

Comments _____

_____

_____

Instructor: _____ (Print/Sign) Date: _____

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

RADIATION WORKER TRAINING

AP-009

REVISION 2.0

Reviewed by:

David Wunsch, Quality Assurance Manager — 4/12/2013 Date

Approved by:

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

1.0 PURPOSE

This procedure establishes the Cabrera Services Inc., (CABRERA) training program that, upon satisfactory completion, will grant individuals permission to perform work with U.S. Nuclear Regulatory Commission (NRC) licensed radioactive material and enter work sites that have radioactive materials.

2.0 APPLICABILITY

This procedure will be used for all CABRERA project work involving both licensed and non-licensed radioactive materials. Compliance with the training provided along with site-specific instruction, will provide a reasonable assurance that project personnel will be aware of their surroundings, the hazards associated with the type of material in the work area, and the type of work conducted.

3.0 DEFINITIONS

3.1 Procedure – A logical, concise document describing the general requirements and methods to be used regarding a specific topic.

3.2 Training – The transfer of information, by instruction, to ensure knowledgeable personnel.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

No individual will be allowed to work with licensed radioactive materials without training qualification and documentation under this program. Certain non-licensed radioactive materials will also require training in receipt and use of dosimetry devices (TLD or OSL).

4.2 Limitations

Any person successfully completing this program will be qualified for a period of one year. Annual refresher training is required to maintain training qualifications. An individual's training will be considered expired 2 weeks after the one year period.

4.3 Requirements

4.3.1 Records of training (training sign-in sheet, qualification test, and/or signed and dated test cover sheet) will be maintained for a period of 3 years. Documentation of previous training, for which credit is being given, will include: individual’s name, date of training, topics covered, and name of the certifying individual. The exam cover sheet must be signed and dated for it to be valid.

4.3.2 The training program for employees and contractors, requiring access to licensed radioactive material will ensure, at a minimum, that the following regulatory requirements are met:

- Title 10 of the Code of Federal Regulations, Part 19.12 (10 CFR 19.12) sets the training requirements for workers, who in the course of employment, are likely to receive an occupational dose in excess of 100 millirem (mrem) (1 milliSievert [mSv]) in a year. They are:
  - At a minimum, four (4) hours of Radiation Safety Training will be required for subcontracted personnel and any worker meeting the condition stated in 10 CFR 19.12(a). This 4 hour training will cover: the topics required in 10 CFR 19.12 (a)(1) through (a)(6); any other pertinent information in 10 CFR Parts 19 and 20; and, the site's NRC license and standard operating procedures.
  - It is mandatory that any females participating in this program receive specific training materials on prenatal radiation exposure (see reference 2).
  - An annual refresher course in Radiation Safety may also be required, and as be such provided and documented. In lieu of the annual refresher course, the individual may take a challenge test consisting of the same questions as presented as part of the 4 hour Radiation Safety Training.
- CABRERA employees who are currently certified by the American Board of Health Physics may be exempted from the 4 hours Radiation Safety Training requirement described in the previous bullet point.

4.3.3 The RSO, or duly authorized representative, will ensure that the training materials and examination given are current, accurate and complete.

4.3.4 Individuals performing a specific limited task, non-invasive work, or requiring access for observation or similar purposes, will be exempt from the requirements in Section 4.3.2, and may be allowed on site if the following requirements are met:

- Prior to entry, the individual has, or will be given, the appropriate radiation, hazardous operations, Right-to-Know, and other site-specific information necessary for the radiological and other hazardous conditions that they may expect to encounter.
- The individual will have the approval of the Radiation Safety Officer (RSO), or duly authorized representative, to enter the site. The RSO, or duly authorized representative, will document this approval by co-signing the individual(s) entry in the site access log or equivalent document.

- Such persons will also have a continuous escort by, or be within continuous view of, a fully trained site representative (e.g. RSO, Site Radiation Safety Lead, or Radiation Protection Technicians).

5.0 EQUIPMENT

- CABRERA Radiation Worker Training Sign-In Sheet
- CABRERA Radiation Worker Presentation
- Radiation Worker Training Instructor Outline (Attachment A)
- Regulatory Guide 8.13 “Instruction Concerning Prenatal Radiation Exposure”
- CABRERA Radiation Worker Qualification Test

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) – The PM is responsible for ensuring that personnel assigned the task of training are adequately trained in the use of this procedure and are knowledgeable in the course subject matter found in Attachment A.

6.2 Radiation Safety Officer (RSO) – The RSO is responsible for verifying that personnel comply with this procedure and are trained in implementing actions described in this procedure.

6.3 Site Radiation Safety Lead (SRSL) – During field assignments, the SRSL is responsible for ensuring that this procedure is implemented and is responsible for identifying training needs. 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 Technician (RPT) – An RPT is responsible for radiation and general safety protection and for counseling workers in proper personal protection from potential hazards. The RPT, performing requirements of this procedure, is responsible for understanding and complying with this procedure.

6.5 All CABRERA Personnel – Are responsible to ensure that their training needs are met to ensure safe and efficient completion of projects.

7.0 PROCEDURE

7.1 This program is designed to include approximately four (4) hours of classroom instruction, practical training as necessary, and time to complete a 50 question multiple choice exam.

7.2 Each individual will be required to achieve, at a minimum, a passing score of 80%. Any individual that scores below 80% but greater than 65% will be

allowed to re-take the test. Those scoring less than 65%will be required to take the 4 hour course again.

7.3 Additional site-specific training will be provided during initial site mobilization. The course instructor may use training aids, which include, but are not be limited to slides, handouts, instruments, etc. to increase trainee understanding of the material being presented.

Note: It is mandatory that any females participating in this program and/or allowed access to radioactive materials, at the site, receive initial specific training materials on prenatal radiation exposure (see Sections 5.0 and 8.0).

7.4 Four Hour Radiation Worker Training

Attachment A is an outline of topics to be covered in the 4 hour radiation worker training. This outline will serve as a general curriculum for instructors. Additional site-specific training includes description of radioisotopes present at the site and equipment used to measure and control exposure to radioactive material while at the site.

7.5 Procedures for operation of instruments, methods of job completion, information important to emergency response, and methods of personnel protection will be discussed with all personnel prior to their job assignments which involve these activities.

7.6 An individual training record will be maintained for each individual assigned to work at CABRERA work sites.

7.7 A review of personnel qualifications will be completed by the individual and reviewed by the PM for each individual hired to perform a specific job function at the project site.

7.8 On-the-job training is as important as other types of training and should be documented when it occurs. An instructor will validate on-the-job training as it occurs. The PM may provide this validation in the absence of an instructor.

8.0 REFERENCES

- NRC, Regulatory Guide 8.29, *Instruction Concerning Risks from Occupational Radiation Exposure*, 1996.
- NRC, Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure*, 1999.
- Institute of Nuclear Power Operations, INPO 93-009, *Guidelines for General Employee Training.*
- Radiation Safety Program, Cabrera Services Inc., Manual
- Radiation Safety Training Manual, Cabrera Services Inc.

- Title 10 Code of Federal Regulation Part 19, *Notices, Instructions and Reports to Workers: Inspection and Investigations*.
- Title 10 Code of Federal Regulation Part 20, *Standards for Protection Against Radiation*.

9.0 REQUIRED RECORDS

- Documentation of on-the-job training
- Individual training record for each employee
- CABRERA Radiation Worker Training Sign-In Sheet
- CABRERA Radiation Worker Qualification Test or, at a minimum, the signed and dated cover sheet will be kept in the students file folder, by the RSO, at the corporate office.

10.0 ATTACHMENTS

Attachment A – Radiation Worker Training Instructor Outline

Attachment A

Radiation Worker Training Instructor Outline

RADIATION WORKER TRAINING INSTRUCTOR OUTLINE

A. INTRODUCTION

1. Goal

Upon successful completion of this program, the individual will have sufficient understanding of Site procedures and basic principles of radiation protection.

2. Health Physics

   a. State the purpose of Health Physics "To protect people and their environment from the harmful effects of ionizing radiation”

   b. Present a description of the Health Physics Department including the basic responsibilities of:

      i. Radiation Safety Officer (RSO)

      ii. Site Radiation Safety Lead (SRSL)

      iii. Radiation Protection Technicians (RPT)

3. Site history

   a. Give a brief description of the history of the Site including:

      i. chronological history

      ii. known hazardous materials

      iii. locations of buried materials

4. Scope of current activities and licensed operations

   a. Give a brief presentation of current activities and licensed activities involving radioactive material on the site. Present general information on the current status of accessible (above ground if any) site contamination. Describe any other hazards that workers may encounter during present and upcoming activities.

B. RADIATION PROTECTION

1. Atomic Structure

a. Atom; Describe the basic structure of the atom

i. Proton - Relative size 1 AMU Positive (+) electrical charge number of protons determines element

ii. Neutron - Relative size 1 AMU, No electrical charge Protons & Neutrons reside in the Nucleus

iii. Electron - Relative size 1/2000 AMU Negative (-) electrical charge Orbits Nucleus

b. A standard atom has equal number of protons and electrons for neutral electrical charge

c. Proton to Neutron ratio equal to 1 in lighter atoms. As atoms get heavier additional neutrons > 1/1 ratio are required for the nucleus to maintain internal balance (stable).

Example:

Hydrogen	1 Proton	0 Neutrons
Oxygen	8 Protons	8 Neutrons
Potassium	19 Protons	20 Neutrons
Iron	26 Protons	30 Neutrons
Lead	82 Protons	126 Neutrons
Thorium	90 Protons	142 Neutrons

d. Isotope; Family of atoms within an element where the nuclei have the same number of protons but differing number of neutrons.

Example:

Element: Thorium, Isotopes: Th-230, Th-232

Th-230: 90 Protons, 140 Neutrons

Th-232: 90 Protons, 142 Neutrons

e. Imbalance in neutron / proton ratio causes atom to be unstable i.e. RADIOACTIVE.

f. Nature strives to be in balance, to stabilize an unbalanced atom the atom emits radiation.

2. Radioactive Material

An unstable atom or group of atoms that, in an effort to become stable emit ionizing radiation.

a. Radioactive Contamination:

i. Radioactive atoms on the surface of non-radioactive material (loose or fixed)

ii. Radioactive material where we don't want it.

b Nuclear Activation:

i. Material not originally radioactive, but activated by exposure to a Nuclear Reactor Core, neutron source, etc.

Example:

^{60}Co

c. Naturally occurring:

i. Radioactive atoms occurring in nature.

3. Radiation

In an effort to balance N/P ratio radioactive isotopes emit ionizing radiation.

Ionization - The removal of an orbiting electron from its parent atom.

There are 4 types of ionizing radiation emitted from unstable atoms. This lecture will deal only with only the 3 natural types of ionizing radiation.

a. Alpha Particles

i. 2 protons (++) 2 neutrons, no electrons (Helium nucleus).

ii. Emitted from nucleus of heavy isotopes.

iii. Ionizes by electrical attraction of electrons (-) by protons (++) in the Alpha particle.

iv. Moves at 1/20 the speed of light (slow by nuclear standards).

v. Ionizes very readily due to slow speed and high electrical (++) charge stopped by sheet of paper.

vi. Hazard to body only if taken internally. Dead layer of skin protects from external sources.

vii. Alpha radiation is greatest internal hazard of the radiation's emitted by isotopes of thorium.

b. Beta Particle

i. Particle emitted from the nucleus of unstable isotope.

ii. Generally (-) electrical charge.

iii. Generated in the nucleus by transformation of a neutron into (+) proton and (-) Beta.

iv. Ionizes by electrical repulsion (-) beta repels electrons.

v. Moves 1/10 the speed of light.

vi. Due to the smaller electrical charge than Alpha, Beta penetrates deeper into materials.

vii. Shielded by 1/4 to 1/2 inch of most solid materials.

viii. External hazard to skin and eyes.

ix. Internal hazard

c. Gamma Ray

i. Packet of energy, no mass (other examples light, radiant heat, radio).

ii. No electrical charge, moves at the speed of light.

iii. Emitted in conjunction with beta radiation's.

iv. Ionizes by other indirect methods based on energy (offer to discuss after class).

v. Very high penetrating power due to no electrical interaction.

vi. Major external radiation hazard with some internal hazard also.

Note: Ensure students understand difference between radiation and radioactive material.

4. Units

a. rem - The unit of measurement for reporting biological damage to humans from radiation energy absorbed in human tissue.

i. Generally reported in fractions of a rem or millirem.

1000 millirem = 1 rem.

ii. Used to report total dose

iii. Used to report dose rate (2 rem/hour = 2000 mrem/hr)

Note: Ensure students have firm understanding of dose and dose rate concepts.

b. DPM - Disintegration Per Minute (Unit of activity)

i. A disintegration is the spontaneous emission of particles (and associated gamma rays) from an unstable nuclei.

ii. DPM - Disintegration Per Minute

5. Measurement

a. TLD

i. Used to measure total external dose (Deep, Skin, Eye)

ii. Demonstrate how worn (Whole Body, Wrist, Finger Rings)

iii. What to do when lost or damaged.

iv. What to do when not in use (storage).

v. Used to determine legal external dose

vi Used to comply with 10 CFR 19 and 20

b. Personnel Friskers

i. Used to measure contamination.

ii. Demonstrate instrument and show proper frisking techniques.

iii. Show how to determine background and readings greater than background

c. Radiation Survey Meter

i. Describe general use of dose rate survey meter.

ii. Compare dose rate reading with total dose reading from TLD.

d. Breathing Zone Air Sampler

i. Discuss use of BZ.

ii. Discuss basic principles of airborne monitoring (DAC) hours.

e. Whole Body Counter / Bioassay

i. As appropriate discuss basic principles of whole body counting (Analysis of gamma rays emitted by RAM in the body).

ii. Discuss Allowable Limit of Intake (ALI-maximum allowable amount of RAM taken inside the body in one year).

iii. Mention other types of BIOASSAY (urine, fecal analysis).

f. Smear Survey

i. Used for determining levels of loose surface contamination.

ii. Explain units DPM/100 cm^2.

iii. Discuss smears.

iv. Discuss loose surface contamination limits (clean):

$\leq$20 DPM/100 cm^2 Alpha

$\leq$ 200 DPM/100 cm^2 Beta/Gamma for Strontium-90 and $\leq$1000 DPM/100 cm^2 Beta/Gamma for all other Beta/Gamma emiters

g. Fixed Contamination Survey

i. Discuss fixed contamination.

ii. Limit for fixed surface:

100 DPM/100 cm^2 Alpha

5000 DPM/100 cm^2 Beta/Gamma or 1000 DPM/100 cm^2 Beta/Gamma

Note: Ensure that all students know that only radiation protection staff may perform radiation and contamination surveys (only exception personnel frisking of body and clothes).

6. Background Radiation

a. Natural sources

i. Radon approximately 200 mrem/year (Rn^{220} from Th^{232}, Rn^{222} from U^{238}). Top 12" in 1 $mile^2$ average in USA 2000 lbs. U, 6000 lbs. Th

ii. Other than Radon approximately 100 mrem/year

(Cosmic, K^{40})

b. Man made

i. Medical, approximately 53 mrem/yr (39 mrem diagnostic x-rays, 14 mrem nuclear medicine)

ii. Fallout < 4.0 mrem/yr (historical bomb testing)

iii. Nuclear fuel cycle <0.1 mrem/yr (U mining, transportation, Nuclear plants, waste disposal).

Note: Maximum allowable public exposure from licensed operations is 100 mrem/yr.

iv. Consumer Products <10.0 mrem/yr (tobacco products, building materials, smoke detectors, drinking water, natural gas)

The average person by age 50 will have a total dose of 30 rem (30,000 mrem) from all sources

The total average dose for all people is 620 mrem/year. This total is based on the total exposure for all Americans divided by population. An individual's dose is dependent on factors such as geographic location and medical history.

7. Occupational Dose

1992: 250,000 Individuals monitored for occupational exposure

125,000 no measurable exposure

125,000 average exposure of 300 mrem

8. Biological Effects

a. Radiation effects on cells of the body.

i. Cell will die.

ii. Cell will repair itself.

iii. No damage.

iv. Cell is damaged, survives, and cannot reproduce.

v. Cell genetic material is damaged, damage is passed on to next generation (mutation).

b. Acute vs Chronic Exposure

i. Acute Exposure - High dose in short period.

ii. Acute effects

<25 rem no readily detectable effects

>25 rem exposure slight changes in blood (MD)

>100 rem vomiting, diarrhea, loss of hair

450 rem LD-50 with no medical intervention

600 rem LD-100 with no medical intervention

c. Chronic exposure - Low dose over long period of time.

Chronic exposure is the basis for our Radiation Program.

d. Stochastic Damage (Cancer)

i. A particular cells level of cancer risk is dependent on how fast the cells reproduce themselves. "Radiosensitivity"

ii. Cancer Statistics, 20% of all adults will develop a fatal cancer from all possible causes.

In a group of 10,000 workers, 2000 will die from cancer. Expose this same group to 1 rem of ionizing radiation (DDE) statistically 4 additional cancers will result (2000 - 2004). For 100 rem 400 additional cancers.

iii. Relative Risk Table:

Hazard	Est. of days lost
Pack of Cigarettes/day	2370 days

20% overweight	985 days
Home accidents	95 days
1 rem lifetime exposure	1 day

Note: Other statistics are available in reg guide 8.29

iv. Somatic Effects - Effects that appear in the exposed individual

v. Genetic Effects - Effects that appear in the exposed individual's offspring

Note: There is no statistical evidence of genetic effects appearing in humans. Genetic effects have been observed in laboratory animals at very high doses.

9. Exposure Limits

a. External Dose Limits

i. Skin SDE 50 rem/yr

ii. Max. Extremity 50 rem/yr

iii. Eyes LDE 15 rem/yr (Cataracts).

b. Total Effective Dose Equivalent TEDE

Limit based on total dose to the body from external sources (Deep Dose [gamma] Equivalent) and doses to the body from internal sources.

TEDE = DDE + CEDE

CEDE = %ALI, 1 ALI = 5 rem CEDE

2000 DAC hours = 1 ALI

TEDE Limit - 5 rem/yr NRC

c. Declared Pregnant Woman (Dose to Embryo/Fetus)

500 mrem TEDE for duration of pregnancy

Low limit due to high radiosensitivity of developing cells

10. Exposure Control

a. Basic concepts for reducing exposure.

i. Time

ii. Distance

iii. Shielding

iv. Source Reduction

b. Radiation Work Permit (RWP)

i. Required for all work with RAM.

ii. Must be modified if work scope changes.

iii. Must be authorized to work under RWP, authorized personnel must be trained.

iv. Contact Radiation Protection to initiate or to add names to an existing RWP.

c. ALARA As Low As is Reasonably Achievable

i. Discuss concept of ALARA principle.

ii. Management's responsibility to provide adequate work facilities and provide training.

iii. Health Physics responsibilities:

- Awareness of jobs in progress

- Perform proper surveys

- Surveillance of work areas

iv. Workers responsibilities:

- Proper knowledge of job requirements

- Inform HP of work scope and changes

- Follow all rules & procedures

Note: Important to stress to all radiation workers that nobody has better control over your actions than yourself. Every rad worker has final responsibility for ensuring a radiologically safe working environment.

11. Posting

Discuss standard posting procedures, include Tri-foil symbol, standard yellow & magenta colors, rad rope and step off pads.

a. Radioactive Material

i. RAM posting indicates the presence of Radioactive Material within the posted area.

b. Radiation Area

i. Indicates that within the posted area radiation dose rates are greater than or equal to 5.0 mrem/hr at 30 centimeters from the radiation source or any surface that the radiation penetrates.

c. Contaminated Area.

i. Indicates that within the posted area loose surface contamination may exist with levels in excess of 20 DPM/100 cm^2 α or 200 DPM/100 cm^2 β, γ.

ii. Requirements for entry into a contaminated area are:

1) Protective Clothing

2) RWP [or HP permission].

12. Miscellaneous Practical Information

a. RAD Waste.

The cost of waste storage for potential disposal is very high

every effort will be made to limit the generation waste.

b. Airborne Contamination.

i. One potential for unnecessary radiation exposure working at a radiologically contaminated site comes from breathing contaminated air.

ii. Sources of airborne contamination:

- Equipment disassembly & repair

- Decontamination operations

- Filing & Grinding

- Mechanical Shock

- Routine equipment operations

iii. It is very important that HP be notified anytime unplanned operations are taking place that could create an airborne situation.

c. Pathways for internal contamination

i. Inhalation

ii. Oral ingestion

iii. Cuts or other skin openings

d. Protective Clothing

i. Display and discuss standard protective clothing, to include:

- Coveralls

- Lab Coat

- Hood

- Shoe Covers

- Gloves (plastic, latex, cloth)

- Safety Glasses

ii. Using a working copy of an RWP select one student to demonstrate proper dressing.

iii. Review other types of protective clothing such as plastic (tyvek) suites, and face shield.

e. Emergencies

i. For medical emergencies:

- For minor illness leave the area & report to the HSA.

- If minor cuts occur, contact HP prior to reporting to medical.

Note: All cuts, scratches, or other skin openings must be checked by HP prior to entry into any contaminated area, or working with radioactive materials.

Note: If major illness or injury occurs DO NOT remove the individual, if qualified perform first aid, if not get help.

The time utilized in removing an individual from a radiological control area during a medical emergency will have a much greater effect on that persons health than any negative effects of treating the individual within the radiological controlled area.

13. Workers' Rights & Responsibilities

a. NRC Form 3

i. Show copy of Form 3, discuss. Give the locations found.

How to report potential violations to the NRC. Rights to obtaining exposure history. Protection from discrimination.

b. Workers responsibilities

i. Stress to all students that they have the greatest responsibility in ensuring a safe working environment.

ii. All persons working with RAM have a legal responsibility to comply with all RWPs, procedures, license requirements and NRC regulations.

Note: Individuals willfully violating safety requirements can be held criminally liable.

c. House Keeping

i. All persons working inside any HP restricted area is responsible for general cleanliness in addition to radiological responsibilities.

14. Facilities Tour & Site-Specific Training

a. All persons unfamiliar with the Site will have a tour of the work areas and a review of the following.

i. Entry and exit requirements including Personnel frisking.

ii. Discussion of contaminated areas including:

Step Off Pads - Posting - Waste Containers

iii. Use of Protective Clothing & Dress out area

iv. Health Physics Office

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

PERSONNEL PROTECTIVE EQUIPMENT USED WITHIN RADIOLOGICAL CONTROL AREAS

AP-010

REVISION 1.0

Reviewed by:

David Wunsch, Quality Assurance Manager — 4/12/2013 Date

Approved by:

Henry Siegrist

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

1.0 PURPOSE

This procedure provides the methods Cabrera Services Inc. (CABRERA) uses to: determine the need for protective equipment; select and wear protective clothing while working in contaminated areas; and, remove protective clothing when exiting contaminated areas under CABRERA control. Adherence to this procedure provides a reasonable assurance that personnel will remain free of contamination and that contamination will not be spread beyond a designated contamination area.

2.0 APPLICABILITY

The protocols and procedures presented apply to all CABRERA personnel, or their subcontractors, working with radioactive materials or within radiologically controlled areas.

3.0 DEFINITIONS

3.1 Restricted Area – An area where 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 ALARA – An approach to radiation exposure control to maintain personnel radiation exposures as far below the federal limit as technical, economical and practical considerations permit.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

There are no precautions associated with this procedure.

4.2 Limitations

This procedure is limited to the donning and doffing of personnel protective clothing. Any usage instructions for personnel protective equipment (PPE) used for particular contaminants at work sites will be covered in the implementation of a site-specific training program for each project site.

4.3 Requirements

ALARA practices will be maintained when using PPE.

5.0 EQUIPMENT

PPE will be selected based on job specific requirements and the Radiation Work Permit (RWP); and, will be specified in Site-Specific Work Plans.

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) – Ensuring that personnel assigned the task of working in contaminated areas are know and understand this procedure, and are adequately trained in its use.

6.2 Radiation Safety Officer (RSO) – Training of personnel in the selection, use, and removal of protective clothing and equipment; as well as, training workers in proper personnel survey techniques when exiting a contaminated area.

6.3 Site Radiation Safety Lead (SRSL) – During field assignments, the SRSL is ensures that this procedure is properly 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) – Complying with the provisions of this procedure when using protective clothing.

7.0 PROCEDURE

Plan work activities before putting on protective clothing and obtain all necessary supplies, instruments, and tools to be used in work activities. This equipment is placed at the entrance to the contaminated area so it can be taken into the area when entry is made. Instrumentation should be placed at the exit or be available for personal surveys when exiting the area.

7.1 Selection of Protective Clothing

7.1.1 Protective clothing is selected to provide a barrier between personnel clothing/skin and radioactive materials that exist in a contaminated area, as defined in the Radiation Safety Program (RSP).

7.1.2 Boots or overshoes are used to prevent contamination spread beyond the designated contamination area.

7.1.3 Cloth or vinyl coveralls are used to intercept contamination before contacting personnel clothing and skin.

7.1.4 Cotton, vinyl, or latex gloves are used to prevent contamination from adhering to hands while handling contaminated surfaces and items in a contaminated area.

7.1.5 Cloth or vinyl caps or hoods are worn to prevent contamination from overhead surfaces from contaminating hair and exposed skin while

working in contaminated areas.

7.2 Methods of Dressing in Protective Clothing

Note: Dress/undress instructions are based on the assumption of using zippered or buttoned protective clothing.

7.2.1 All protective clothing is selected and donned before entering the contaminated area.

7.2.2 First put on coveralls and close flaps provided on the coveralls. If specified on the RWP, place a strip of tape over pocket openings and front zipper or button flaps. Fold over the tape at one end to provide a tab for easier removal of the tape when exiting the area.

7.2.3 Put cloth or plastic booties on over personnel shoes, overshoes over booties and place coverall pant legs over the overshoe tops. Tape the overall pant legs to the bootie tops leaving a tape tab for easy removal of bootie top.

7.2.4 Place cloth cap or hood on head. If using a hood, tape flap to outside of coveralls. If wearing a respirator, ensure hood is taped to respirator.

7.2.5 Put on gloves with coverall sleeves over the gloves. Tape coverall cuffs to gloves to provide a seal at the joints. Leave tab at the end of tape for easy removal. If high levels of contamination are anticipated, a second pair of gloves may be worn under the taped pair.

7.2.6 After entering the contaminated area, a complete survey of clothing must be made, as described in Section 7.3, before exiting the area.

7.2.7 If light work activities (such as surveys) are performed in the contaminated area, taping coverall sleeves, cuffs, and flaps is not required.

7.3 Work Techniques and Contamination Area Hygiene

7.3.1 While working in a contaminated area, minimize contact with surfaces and items to the extent possible. All surfaces and items located in a contaminated area are considered contaminated and contact with surfaces and items will transfer contamination to protective clothing.

7.3.2 While in the contaminated area, do not touch face, glasses, or exposed skin with gloves or other protective clothing.

7.3.3 If clothing became torn or ripped during work activities, cover opening with tape to prevent contamination from further penetration of protective clothing.

7.3.4 Avoid work activities that may create airborne activity, to the extent possible.

7.3.5 Workers must not eat, drink, chew, or smoke while wearing protective

clothing in a contaminated area.

7.4 Procedures for exiting a contaminated area

7.4.1 Protective clothing is removed when exiting a contaminated area, in such a manner, as to control contamination from spreading beyond the designated boundary of the contaminated area.

7.4.2 If a second set of gloves is used, the outer set of gloves is removed before starting the un-suiting procedure.

7.4.3 Remove hood coveralls cuffs and coverall pant legs, if used.

7.4.4 Remove hood or cap by handling external surfaces and place in a protective clothing receptacle.

7.4.5 Remove overshoes, by only handling external surfaces, and place them in a protective clothing receptacle. With the overshoes removed, retain plastic booties and remain inside the area to continue removing protective clothing.

7.4.6 Undo the coverall flap and remove, by handling only the external surfaces. Slip coverall pant legs over booties and place them in a protective clothing receptacle.

7.4.7 With your back toward the step-off pad, remove the plastic booties and step off the pad with personnel shoes on.

7.4.8 While standing on the step-off pad, remove the gloves by handling external surfaces and deposit them in a protective clothing receptacle.

7.4.9 Perform a personnel survey by first surveying hands with an alpha and/or beta survey meter. After determining hands are free of contamination, pick up instrument and survey shoes, personnel clothing, face, and hair with a survey meter to determine if surfaces are contaminated. If contamination is found above limits in the RSP, contact RSO, or their duly authorized representative at the site, for decontamination instructions.

8.0 REFERENCES

- Radiation Safety Program, Cabrera Services Inc., Manual
- OP-001, *Radiological Surveys*, Cabrera Services Inc., Operating Procedure
- OP-020, *Operation of Contamination Survey Meters*, Cabrera Services Inc., Operating Procedure
- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure

9.0 REQUIRED RECORDS

There are no required records associated with this procedure.

10.0 ATTACHMENTS

None

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Packaging Radioactive Material

AP-013

Revision 0

Reviewed By: _____ Date: 1/24/00
David Watters, Radiological Safety Engineer

Approved By: _____ Date: 1/24/00
Steven Masciulli CHP, CSP, Radiation Safety Officer

Approved By: _____ Date: 1/24/00
Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

This procedure describes the methods used by trained Cabrera Services, Inc., (CABRERA) employees at customer facilities to package material for disposal as radioactive waste. Adherence to this procedure will provide reasonable assurance that personnel exposures will be ALARA, personnel will remain free of contamination, and contamination will not be spread beyond the designated contaminated area.

2.0 APPLICABILITY

This procedure will be used to ensure packaging of radioactive waste meets Federal, State, Customer, and Waste Site requirements.

3.0 PRECAUTIONS, LIMITATIONS, AND REQUIREMENTS

3.1 Precautions

3.1.1 Protective Equipment (e.g., gloves, coveralls, etc.) will be used if required during the handling of radioactive material.

3.2 Limitations

3.2.1 If loose surface contaminated material is to be handled, ensure the evolution is set up in an approved area and that the ventilation system for the area is in operation and respiratory protection requirements have been determined and specified in the RWP.

3.3 Requirements

3.3.1 Ensure that a Radiation Work Permit (RWP) has been issued to control the evolution. The RWP may be written to govern multiple tasks.

3.3.2 All personnel packaging waste shall comply with RWP requirements.

3.3.3 The Attached Container Checklist, AP-013-01 will be used during the packaging is materials.

4.0 REFERENCES

- RSP Radiation Safety Program
- AP-001 Record Retention
- AP-010 Personnel Protective Equipment
- AP-012 Radiation Work Permit
- AP-015 Radioactive Materials Brokering

- AP-016 Radioactive Material Tracking
- OP-001 Radiological Surveys
- OP-019 Radiologically Restricted Areas
- OP-020 Operation of Contamination Survey Meters
- OP-021 Alpha-Beta Sample Counting Instrumentation
- OP-023 Operation of Micro-R Survey Meters
- OP-022 Operation of Ionization Chambers
- NUREG-1556 Consolidated Guidance About Material Licenses - Vol. 11

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 No detectable freestanding liquid – As little liquid as reasonable achievable, but in no case shall the liquid exceed 0.5% of the waste volume.

5.2 Sorbent Material – Sorbent material approved by applicable regulatory body for use at designated disposal site. Approved sorbents are listed in the applicable disposal facility license.

5.3 Strong Tight Container – Container capable of transporting radioactive material to the disposal facility without loss of material.

5.4 Heavy Duty Closure Ring – Closure ring for drums of 55-gallons or larger capacity secured by a both having a 5/8" or larger diameter.

5.5 Container – Outer package which meets strong tight criteria. Containers are most commonly steel drums of 55-gallons capacity or larger.

6.0 EQUIPMENT

- Appropriate containers
- Packaging materials, as needed
- Tools for securing containers

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – The PM is responsible for ensuring that all personnel assigned the task of packaging containers of radioactive material are familiar with this procedure and are adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation Safety Officer (RSO) – The RSO is responsible for training of personnel working with radioactive material. The RSO ensures HPT are qualified by training and experience to perform the requirements of this procedure.

7.3 Radiological Field Supervisor (RFS) – During field assignments, the RFS is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the RFS will act as the RSO's duly authorized representative for radiological issues.

7.4 Health Physics Technicians (HPT) – The HPT are responsible for control of radioactive material.

8.0 INSTRUCTIONS

8.1 The RFS or RSO will initiate a RWP describing the work to be done. The HPT will perform all required surveys and prescribe requirements as specified in procedure AP-012.

8.2 Packaging Dry Material

8.2.1 Ensure container:

- Has a heavy closure ring, which is free of defects.
- Exhibits no holes, damage, or deformation, which renders the container non-strong tight.
- Gasket exhibits no apparent damage.
- Ensure the package meets the appropriate performance testing criteria for the material being packaged per Title 49 of the Code of Federal Regulations.

8.2.2 Place a thin layer of approved sorbent material in the bottom of the container.

8.2.3 Place pellets or other material into the container, filling as much of the volume as practical.

8.2.4 Fill void spaces within the container with dry material to the maximum extent practical.

8.2.5 Ensure the container contains no detectable freestanding liquid.

8.2.6 Install lid and fasten closure ring securely. Tap the closure ring with a hammer around the edges while tightening the closure ring bolt.

8.2.7 Ensure drainage/sample bung is closed securely and cover bung joint with waterproof caulk.

8.2.8 Weigh the completed container.

8.2.9 Provide tracking information as required by AP-016.

8.2.10 Label container with following information.

- Radioactive Material
- Container identification number
- Gross weight

8.2.11 Complete Container Checklist, AP-013-01.

8.2.12 Have health physics personnel perform dose rate survey of completed containers.

8.3 Packaging Biological Material (excluding animal carcasses)

Warning: Containers with biological, pathologic, or infections materials or equipment used in handling of such material shall be kept sealed except when an appropriate work area has been established and specific procedures are written to repackage the material.

8.3.1 Ensure that the shipper has provided certification to ensure the following:

- Each received container meets DOT 7A Performance Specifications or was manufactured to DOT 17H Specifications.
- Each received container is lined with a sealed plastic liner, minimum 4 mil-thickness.

8.3.2 Select a container with a capacity of at least.

- 40% greater than the received container for disposal in Washington.
- 50% greater than the received container for disposal in South Carolina.

8.3.3 Ensure the outer container.

- Meets DOT 7A Performance Specifications and test records are on file.
- Has a heavy-duty closure ring, which is free of defects.
- Exhibits no holes, damage, or deformation, which renders the

container non-strong tight.

- Has a gasket, which exhibits no damage.
- Ensure the package meets the appropriate performance testing criteria for the material being packaged per Title 49 of the Code of Federal Regulations.

8.3.4 Place a layer of approved sorbent material in the bottom of the outer container.

8.3.5 Place received container into the outer container.

8.3.6 Fill void spaces within the container with approved sorbent material, and ensure there is no detectable freestanding liquid.

8.3.7 Install lid and fasten closure ring securely.

8.3.8 Ensure drainage/sample dung is closed securely, and cover bung joint with waterproof caulk.

8.3.9 Weigh the completed container.

8.3.10 Provide tracking information as required by AP-016.

8.3.11 Label container with the following information:

- Radioactive Material
- Container identification number
- Gross weight

8.3.12 Complete Disposal Container Checklist.

8.3.13 Place the completed container in an appropriate storage area.

8.4 Packaging Bulk Dry Material

Note: This section is intended for use in preparing large containers (50 ft^3 or more) for disposal. Items, which can be placed in drums, should be packaged as described in Section 8.2.

8.4.1 Inspect container to be sued as a burial container to ensure:

- No holes damage, or deformation, which renders the container non-strong tight.

- Lid gasket exhibits no apparent damage.
- Closure devices are free of defects.
- Ensure the package meets the appropriate performance testing criteria for the material being packaged per Title 49 of the Code of Federal Regulations.

8.4.2 Place waste material inside the container, filling as much of the volume as practical.

8.4.3 Ensure the container has no detectable freestanding liquid.

8.4.4 Install lid and fasten securely using one or more of the following:

- Clips
- Mechanical fasteners
- Clamping rings
- Metal banding

8.4.5 Ensure drainage/sample plug is closed securely and cover drain plug with weatherproof caulk.

8.4.6 Determine the completed container weight.

8.4.7 Provide tracking information as required by AP-016.

8.4.8 Label container with following information.

- Radioactive Material
- Generator(s) identification and receipt number(s)
- Container identification number
- Gross weight

8.4.9 Complete Container Checklist, AP-013-01.

8.4.10 Have Radiation Staff Members perform dose rate survey of completed containers.

8.4.11 Place completed container in appropriate storage area.

8.5 Packaging Solidified or Stabilized Liquid

Note: This section does not constitute a solidification or stabilization process plan. This section is provided to ensure proper packaging for disposal of liquids, which have been stabilized/solidified in accordance with an approved procedure. This section may be performed concurrent with the stabilization/solidification process.

8.5.1 Review process information and maintain records to ensure:

- Liquid was rendered non-corrosive (4<Ph<11).
- Liquid has been acceptable stabilized or solidified using material authorized in applicable disposal facility license.

8.5.2 Ensure container.

- Has a heavy closure ring, which is free of defects.
- Exhibits no holes, damage, or deformation, which renders the container non-strong tight.
- Gasket exhibits no apparent damage.
- Ensure the package meets the appropriate performance testing criteria for the material being packaged per Title 49 of the Code of Federal Regulations.

8.5.3 Fill container with material to be stabilized or solidified.

8.5.4 Fill void spaces within the container with sorbent material, and ensure there is no detectable freestanding liquid. Void space shall be less than 15% of container volume.

8.5.5 Install lid and fasten closure ring securely.

8.5.6 Ensure drainage/sample bung is closed securely and cover bung joint with waterproof caulk.

8.5.7 Determine the completed container weight.

8.5.8 Provide tracking information as required by AP-016.

8.5.9 Label container with following information.

- Radioactive Material
- Container identification number

- Gross weight

8.5.10 Complete Container Checklist, AP-013-01.

8.5.11 Have Radiation Staff Members perform dose rate survey of completed containers.

8.5.12 Place completed containers in an appropriate storage area.

8.6 Packaging Sorbed Liquid

Note: This section does not constitute a sorption process plan. This section is provided to ensure proper packaging for disposal of liquids, which have been sorbed in accordance with an approved procedure. This section may be performed concurrent with the sorption process. For disposal at other than the Barnwell site.

8.6.1 Review process information and maintain records to ensure:

- Liquid was rendered non-corrosive (4<Ph<11).
- Liquid has been acceptable stabilized or solidified using material authorized in applicable disposal facility license.
- Liquid is contained in enough sorbent material to sorb at least twice the volume of the liquid content.
- Volume and weight of unprocessed liquid has been recorded.

8.6.2 Ensure container.

- Has a heavy closure ring, which is free of defects.
- Exhibits no holes, damage, or deformation, which renders the container non-strong tight.
- Gasket exhibits no apparent damage.
- Meets DOT 7A Performance specifications and test records are on file.

8.6.3 Line the container with a minimum 4-mil plastic liner unless liquid has been sorbed in Petroset, Aquaset, or equivalent.

8.6.4 Fill container with sorbed material as fully as possible.

8.6.5 Fill void spaces within the container with sorbent material and ensure there is no detectable freestanding liquid.

8.6.6 Close plastic liner.

8.6.7 Install lid and fasten closure ring securely.

8.6.8 Ensure drainage/sample bung is closed securely and cover bung joint with waterproof caulk.

8.6.9 Weigh completed container.

8.6.10 Provide tracking information as required by AP-016.

8.6.11 Label container with following information.

- Radioactive Material
- Container identification number
- Gross weight

8.6.12 Complete Container Checklist, AP-013-01.

8.6.13 Have Radiation Staff Members perform dose rate survey of completed containers.

8.6.14 Place completed container in an appropriate storage area.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 Quality Control verification of packaging activities will be performed on a recurring surveillance basis and will be documented on a QA Surveillance Report.

9.1.2 Surveillance may be performed during packaging or by opening and inspecting previously packaged material

9.1.3 Instrumentation used for measurements required by this procedure will be checked with standards and verified to have current calibration.

9.2 Records

9.2.1 Documented information shall be legible and written in ink.

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

9.2.3 The HPT shall ensure that the attachments are of the most current.

9.2.4 The HPT shall review completed attachment forms for accuracy and completeness.

9.2.5 Entries on forms must be dated and initialed by the HPT to be valid.

9.2.6 The RSO or duly authorized representative shall review any applicable completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

AP-013-01 Disposal Container Checklist

Disposal Container Checklist
AP-013-01

Container Number: _____

Container Description: _____

Generator(s): _____

Receipt No.(s): _____

		SAT	N/A
1)	Container Proper for Contents	.	☐
2)	Container Has:		
	- No Holes, Damage, or deformation rendering it non-strong tight	☐	☐
	- Acceptable Closure Equipment	☐	☐
	- Acceptable Closure Gasket	☐	☐
3)	No Free-Standing Liquid	☐	☐
4)	Container Closure Hardware Installed Securely	☐	☐
5)	Container Labeled With Following:	☐	☐
	- Radioactive Material	☐	☐
	- Generator Identifications	☐	☐
	- Container identification Number	☐	☐
	- Gross Weight	☐	☐

Completed By: _____ Date: _____
Operator Signature

Reviewed By: _____/_____ Date: _____
Print/Sign

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Classifying Radioactive Waste

AP-014

Revision 0

Reviewed By: _____ Date: 1/24/00

David Watters, Radiological Safety Engineer

Approved By: _____ Date: 1/24/00

Steven Masciulli CHP, CSP, Radiation Safety Officer

Approved By: _____ Date: 1/24/00

Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

The purpose of this procedure is to establish instructions by Cabrera Services, Inc. (CABRERA) used to classify waste for disposal; complete shipment manifest; and verifies waste receipt criteria. Adherence to this procedure will provide reasonable assurance that waste will be properly classified pursuant too 10 CFR 61.

2.0 APPLICABLITY

2.1 This procedure will be used to classify wastes pursuant to 10 CFR 61. Waste classification considerations for disposal at a licensed facility require:

2.1.1 Consideration must be given to the concentration of long-lived radionuclides (and their shorter-lived precursors).

2.1.2 Consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste, form, and disposal methods are effective.

2.2 Description of Procedures

2.2.1 Use of this procedure will demonstrate the methodology for determining:

- If the waste is acceptable for near-surface disposal.
- It the waste is acceptable for near-surface disposal, whether the waste is classified as Class A, Class B, or Class C waste.

2.2.2 Using this procedure CABRERA personnel will be able to determine whether the waste complies with any additional waste form, package or content requirement, which may be in place at the particular disposal facility to which the waste is to be shipped.

3.0 PRECAUTIONS, LIMITAITONS, AND REQUIREMENTS

3.1 Minor differences may exist between individual disposal facilities and the Waste Class tables presented in this procedure. ALWAYS classify waste per the destined facilities criteria.

3.2 The Barnwell facility has a Class C determination form that must be completed and forwarded with the shipment.

3.3 US Ecology facility has a NARM determination required to be completed before shipment.

3.4 Certain waste streams such as filter resins etc. also require isotopic analysis to be completed before shipment.

4.0 REFERENCES

- 10 CFR Part 61
- CNSI Barnwell Waste Management Facility License
- US Ecology Hanford License
- Envirocare Utah Department of Environmental Quality Radioactive Material License

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Class A Waste – Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and waste characteristics of Class A waste must meet the minimum requirements set forth in 10 CFR 61.56(a). If Class A waste also meets the stability requirements set forth in 10 CFR 61.56(b), it is not necessary to segregate the waste for disposal.

5.2 Class B Waste – Class B waste is waste that must meet more rigorous requirements on waste from to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in 10 CFR 61.56.

5.3 Class C Waste – Class C waste is waste that not only must meet more rigorous requirements on waste from to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in 10 CFR 61.56.

6.0 EQUIPMENT

None

7.0 RESPONSIBLITES

7.1 Project Manager (PM) – The PM is responsible for ensuring that all personnel assigned the task of waste classification are familiar with this procedure and are adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation Safety Officer (RSO) – The RSO is responsible for quality audits of waste classification performed by the Waste Broker.

7.3 Waste Broker – The Waste Broker is responsible to collect all required information about the waste and classifying the waste as outlined in this procedure.

8.0 INSTRUCTIONS

8.1 Procedural determination of concentration may be made by using the following individually or in combination.

8.1.1 Compliance through materials accountability, a given quantity (and resulting concentration) of radioactive material may be known to be contained within a given waste or may be inferred through determining the difference between the quantity of radioactive material entering and exiting a given process.

8.1.2 Classification by source is similar to the above method of materials accountability and involves determining the radionuclide content and classification of waste through knowledge and control of the source of the waste.

8.1.3 Gross radioactivity measurements is an acceptable method for all classes of waste provided that:

- The gross radioactivity measurements are correlated on a consistent basis with the distribution of radionuclides within the particular waste stream analyzed, and

- The radionuclide distributions are initially determined and periodically verified by direct measurement techniques.

8.1.4 Measurements of specific radionuclides may establish an inferential measurement program whereby concentrations of radioisotope which cannot be readily measured (through techniques such as gamma-spectral analysis) are projected through rationing to concentrations of radioisotopes which can be readily measured.

8.1.5 The concentration of a radionuclide may be averaged over the volume of the waste or weight of the waste if the units are expressed as nanocuries per gram (using NRC Branch Technical Position Paper on Waste Classification current revision). For double packaged containers, only the inner package volume may be used for classification.

8.2 Preferred Waste Classification Procedure

This algorithm for waste classification is performed using a computer when available. When using a computer ensure data entry is accurate. Waste classification is to be performed by the Waste Broker with quality review performed by the RSO or duly authorized representative.

8.2.1 Classification determined by long-lived radionuclides. If the waste contains only radionuclides listed in Table I classification is be determined as follows:

- If the concentration does not exceed 0.1 times the value in Table 1, the waste is Class A.
- If the concentration exceeds 0.1 times the value in Table 1, but does not exceed the value in Table 1, the waste is Class C.
- If the concentration exceeds the value in Table 1, the waste is not generally acceptable for near-surface disposal.
- For waste containing mixtures of radionuclides listed in Table 1, the total concentration shall be determined by the sum of fractions rule.
- Site-specific variations to Tables 1 and 2 may exist. Prior to classifying waste, verify that correct numbers are being used for the planned disposal facility.

Table 1

Radionuclides	Concentration Curies/Cubic Meter
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha emitting transuranic radionuclides with T1/2 >5 years	100[1]
Pu-241	3,500[1]
Cm-242	20,000[1]
Ra-226	100[1]

[1] Units are in nanocuries per gram; to convert to becquerels (Bq) per gram multiply by 37, to convert from curies to gigabecquerels (GBq) multiply by 37. Specific approval of SCDHEC (South Carolina) is required for disposal of these radionuclides if their concentration is greater than ten percent of the Table 1 values.

8.2.2 Classification determined by short-lived radionuclides. If the waste does not contain any of the radionuclides listed in Table 1, classification shall be determined based on the concentration shown in Table 2. If the radioactive waste does not contain any radionuclides listed in either Table 1 or 2 its is Class A.

8.2.2.1 If the concentration does not exceed the value of Column 1, the waste is Class A.

8.2.2.2 If the concentration value exceeds the value in Column 1, but does not exceed the value in Column 2, the waste is Class B.

8.2.2.3 If the concentration value exceeds the value in Column 2, but does not exceed the value in Column 3, the waste is Class C.

8.2.2.4 If the concentration value exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.

8.2.2.5 For waste containing mixtures of the radionuclides listed in Table 2, the total concentration shall be determined by the sum of fractions rule.

8.2.2.6 Site-specific variations to Table 2 may exist. Prior to classifying waste, verify that correct numbers are being used for the planned disposal facility.

Table 2

Radionuclide	Concentration Curies/Cubic Meter		
	Column 1	Column 2	Column 3
Total of all radionuclides with T1/2 <5 years	700	(*)	(*)
H-3	40	(*)	(*)
Co-60	700	(*)	(*)
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

(*) There are no limits established for these radionuclides in Class B or C wastes. Practical consideration such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes are Class B unless the concentration of other radionuclides in Table 2 determine the waste to be Class C independent of there radionuclides. Specific approval of SCDHEC is required prior to packaging of Class B tritium waste.

8.2.3 Classification determined by both long-lived and short-lived radionuclides. If the waste contains a mixture of radionuclides some of which are listed in Table 1 and some of which are listed in Table 2 classification shall be determined as follows.

- If the concentration of a radionuclide listed in Table 1 is less than 0.1 times the value listed in Table 1 the class shall be that determined by concentration of radionuclides listed in Table 2.

- If the concentration of a radionuclide listed in Table 1 exceeds 0.1 times the value listed in Table 1 the waste shall be Class C provided the concentration of radionuclides listed in Table 2 does not exceed the value shown in Column 3 of Table 2.

8.2.4 Classification of waste with radionuclides other than those listed in Tables 1 and 2. If the waste does not contain any radionuclides listed in either Table 1 or 2, its is Class A.

8.2.5 The sum of fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each radionuclides concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column.

Example: A waste contains Sr-90 in a concentration of 50 Ci/m^3 and Cs-137 in a concentration of 22 Ci/m^3. Since the concentrations both exceed the values in Column 1, Table 2, they must be compared to Column 2 values. For Sr-90 fraction, 50/150 = 0.33; for Cs-137 fraction, 22/44 = 0.5; the sum of the fractions = 0.83. Since the sum is less than 1.0, the waste is Class B.

8.2.6 Determine package type in accordance with 49 CFR 173.431, 173.433, and 173.435.

8.2.7 Determine if R.Q. marking is required using 49 CFR 172.101 Appendix Table 2.

8.2.8 Verify LSA concentrations with 49 CFR 173.403(N).

8.2.9 Any items exceeding a destination facility license shall not be shipped refer to destination facility license. If material does not comply with license for the facility, the shipment ID going to the waste will not be accepted.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

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

9.1.2 Waste classification will be documented on AP Form 014-01 or may be computer generated.

9.1.3 Waste classification will be documented when shipping radioactive material to the burial site in accordance with waste broker standard procedures.

9.2 Records

9.2.1 Documented information shall be legibly written in ink or equivalent computer generated form.

9.2.2 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.

9.2.3 The individual determining the classification shall review Form AP-014 and any other applicable forms for accuracy and completeness.

9.2.4 Entries on Form AP-014-01 and any other pertinent forms must be dated and initialed by the individual determining the classification to be valid.

9.2.5 The RSO or duly authorized representative shall review any applicable completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

AP-014-01 Waste Classification Form

WASTE CLASSIFICATION WORKSHEET

Form AP-014-01

Generator: _____

Container Number: _____

Container Weight: _____

Container Volume: _____

Package Type: _____

Type A Fraction: _____

RQ Labeling: _____

LSA Concentration: _____

Table 1 Class: _____

Table 2 Class: _____

RADIONUCLIDE QUANTITIES IN THIS CONTAINER (mCi)

_____

_____

_____

_____

Totals: _____ Weight of Waste: _____ LBS

Performed By: _____ Date: _____

Reviewed By: _____ Date: _____

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Radioactive Material Tracking

AP-016

Revision 0

Reviewed By: _____ Date: 1/24/00

David Watters, Radiological Safety Engineer

Approved By: _____ Date: 1/24/00

Steven Masciulli CHP, CSP, Radiation Safety Officer

Approved By: _____ Date: 1/24/00

Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

This procedure describes the requirements associated with tracking radioactive material at Cabrera Services, Inc. (CABRERA) job sites and during any work at customer facilities where procedures for radioactive material tracking are not available in the customer's radioactive material license. Adherence to this procedure will provide reasonable assurance that personnel exposures will be below specified limits, personnel will remain free of contamination, and contamination will not be spread beyond the designated contaminated area.

2.0 APPLICABILITY

This procedure will be used to ensure tracking of radioactive material is done in accordance with State, Federal, and Licensee requirements.

3.0 PRECAUTIONS, LIMITATIONS, AND REQUIREMENTS

3.1 Precautions

3.1.1 Accurate and timely handling of all documentation, including inventory updates, are essential to maintaining radioactive material tracking.

3.2 Limitations

3.2.1 No material may be placed within 10 feet of a Radiological Control Area (RCA) boundary.

3.2.2 Material may not be placed such that exposure rates at the restricted area boundary exceed 100 μR/hr.

3.3 Requirements

3.3.1 Ensure receipt documents have been reviewed and shipments to be received have been approved by the RSO or duly authorized representative prior to initiation of unloading.

3.3.2 Inform the RSO or duly authorized representative any time the site inventory exceeds or potentially may exceed the limits in the facility license.

3.3.3 If any material is found or moved that does not have legible identification contact material controllers or the RSO or duly authorized representative immediately.

3.3.4 All forms and attachments may be computer files and reports.

4.0 REFERENCES

- RSP Radiation Safety Program
- AP-001 Record Retention
- OP-001 Radiological Surveys
- OP-020 Operation of Contamination Survey Meters
- OP-021 Alpha-Beta Counting Instrumentation
- NUREG-1556 Consolidated Guidance About Material Licenses (Vol.11)

5.0 DEFINITIONS AND ABBREVIATIONS

None

6.0 EQUIPMENT

None

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – The PM is responsible for ensuring that all personnel assigned the tasks of control and tracking of radioactive material are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation Safety Officer (RSO) – The RSO is responsible for training of personnel working with radioactive material. The RSO ensures HPT are qualified by training and experience to perform the requirements of this procedure.

7.3 Radiological Field Supervisor (RFS) – During field assignments, the RFS is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the RFS will act as the RSO's duly authorized representative for radiological issues.

7.4 Health Physics Technicians (HPT) – The HPT is responsible for control of radioactive material.

8.0 INSTRUCTIONS

8.1 Tracking and Movement of Radioactive Material

8.1.1 Anytime licensed radioactive material is moved, the person who performed the operation or directed the operation shall ensure completion of the Material Tracking Documentation, Form AP-016-01.

8.1.2 The following are requirements for Material Tracking:

8.1.2.1 Refer any questions to the material controller or RSO or duly authorized representative.

8.1.2.2 Any item moved out of a radiological contamination boundary is surveyed and the survey documented.

8.1.2.3 All forms should be returned to material controllers by the end of each workday.

8.1.2.4 For material transferred to another area such as another work zone or facility, a copy of the Material Tracking document shall be sent to the supervisor of that area.

8.1.2.5 An item generated from another item such as a large container into smaller boxes should be numbered with the original number followed by a dash (-) and a sequential number.

8.1.2.6 Any item, which cannot be easily numbered, shall be referred to the material controller for resolution as soon as possible.

8.1.2.7 Any item for disposable or returned shall be documented.

8.1.2.8 The inventory system should be updated within 48 hours of any changes.

8.2 This procedure shall be in effect at all CABRERA work sites where:

- The total activity of any source is greater than 10 mCi unless the source is of a volumetric nature (i.e. soil), in which case the volumetric activity concentration must exceed 1000 pCi/gram;
- The PM determines that tracking is needed.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 Instruments used for measurements required by this procedure shall be checked with standards and verified to have current calibration.

9.1.2 Surveillance shall be performed at least annually to verify that operations are within the guidelines of this procedure.

9.1.3 A current radionuclide inventory record shall be produced monthly.

9.1.4 Record results of equipment surveys on survey forms in accordance with appropriate survey form.

9.1.5 Maintain AP-016-01 tracking forms for at least three months after the material has been shipped from the work site.

9.2 Records

9.2.1 Documented information shall be legibly written in ink.

9.2.2 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.

9.2.3 The HPT performing the tracking shall ensure that this procedure is the most current and approved revision.

9.2.4 The HPT performing the tracking shall review Form AP-016-01 for accuracy and completeness.

9.2.5 Entries on Form AP-016-01 and any other pertinent forms must be dated and initialed by the HPT performing the tracking to be valid.

9.2.6 The RSO or duly authorized representative shall review completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

AP-016-01 Material Tracking Form

AP-016-01
Material Tracking Form

To prevent the loss of control of radioactive material, note any movement of radioactive material on the site on this form.

ITEM NUMBER	ITEM NAME	ORIGINAL LOCATION	CURRENT LOCATION

Performed by: _____ Date: _____

Reviewed by: _____ Date: _____

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)						circle one
Direct Count (CPM/Direct Frisk)						
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

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

RADIOACTIVE AIR SAMPLING AND ANALYSIS

OP-002

REVISION 1.0

Reviewed by:

David Wunsch, Quality Assurance Manager	4/12/2013 Date

Approved by:

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

1.0 PURPOSE

This procedure provides the methods Cabrera Services Inc. (CABRERA) uses in the operation of air samplers and the calculation of radioactive particulate activity in air samples. This procedure describes the methods used to calculate Derived Air Concentration (DAC)-hour exposures to workers. Adherence to this procedure will provide a reasonable assurance that the surveys performed have accurate and reproducible results.

2.0 APPLICABILITY

This procedure will be used by CABRERA personnel to operate air samplers during surveys and work activities at customer facilities as well as calculate and record DAC-hour exposures to workers.

Air samples are considered when the alpha and beta contamination on facility surfaces, equipment and waste packages exceed the contamination limits specified in Table 1 of the Radiation Safety Program (RSP) and included as Attachment C of this procedure. Air monitoring will be performed in areas where there exists potential to exceed 10 percent (%) of any radionuclide DAC.

3.0 DEFINITIONS

3.1 Restricted Area – An area where access is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted areas do not include areas used as residential quarters, but separate rooms in a residential building may be set apart as restricted areas.

3.2 Smear Sample Survey – A survey technique using filter paper smears to determine quantities of alpha and beta emitting radioactive material which can be removed from facility surfaces and waste packages.

3.3 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.

3.4 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.

3.5 Derived Air Concentration (DAC) – DAC is the concentration of a given radionuclide in air which, if breathed by “reference man” for a working year (40 hours per week for 50 weeks) under the conditions of light work (inhalation rate

of 1.2 cubic meters of air per hour), results in an air intake of one ALI.

3.6 DAC-hour – The product of the concentration of radioactive material in air, expressed as a multiple of the DAC for each nuclide, and the time of exposure to that nuclide in hours; 2,000 DAC-hours represents one ALI.

3.7 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 in excess of:

- The DACs specified in Table 1 Column 3 of Appendix B, Title 10, Code of Federal Regulations, Part 20 (10 CFR 20), or
- 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 ALI, or 12 DAC-hours.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

4.1.1 Air samples run at altitudes in excess of 5,000 feet need to consider pressure adjustments for altitude and recorded flow-meter readings.

4.1.2 Air sample media will tear if the filter comes into contact with water. Outdoor sampling requires special consideration to ensure an effective sample is obtained.

4.2 Limitations

Air samplers should only be operated in temperatures between -4^0 F to 122^0F.

4.3 Requirements

4.3.1 Air sampler inspections will be performed by qualified Health Physics personnel.

4.3.2 The alpha and beta counter used to count air samples will be calibrated daily with a known radioactive source with activity traceable to the National Institute of Standards and Technology (NIST).

4.3.3 Radiation Protection Technologists (RPTs) performing air sampling and analysis will review all applicable forms for accuracy and completeness. Entries on all pertinent forms must be dated and initialed, by the RPT performing the air sampling and analysis, to be valid.

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

5.0 EQUIPMENT

- Low volume general area sampler: LV-1
- High volume air sampler: HI-Q
- Personal Breathing zone samplers: BZ

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) – Ensuring that personnel assigned the task of air sampling and air analysis know and understand this procedure and are adequately trained with the specific instrument(s) being used to perform surveys.

6.2 Radiation Safety Officer (RSO) – Monitoring compliance with this procedure and training personnel in the use of the air sampling and air sampling analysis equipment. 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 the RSO's duly authorized representative for radiological issues when the RSO is not onsite, and is responsible for ensuring that this procedure is properly implemented.

6.4 Radiation Protection Technician(s) (RPT) – The RPT(s) performing air sampling and air sampling analysis are responsible for knowing, understanding and complying with this procedure.

7.0 PROCEDURE

7.1 Initial Preparation

7.1.1 Select the air sampler to be used, for the type of sample to be used, and verify that the instrument has a currently valid calibration. If the work area contains radioiodine or tritium, contact the RSO for special sampling procedures before proceeding.

- Area air samples are collected with a low volume air sampler (LV-1) having airflow capability of 20 to 100 liters per minute (LPM) and are routinely set at 80 LPM.
- Area air samples are collected with high volume air samplers (HI-Q) having airflow capability of 10 to 50 cubic feet per minute (CFM) and are routinely set at 15 to 40 CFM, depending upon the filter size used.
- Breathing zone (BZ) air samples are normally collected using BZ, or lapel air samplers, which have an airflow capability of 1 to 5 LPM

and are calibrated and set at 4 LPM for radiological air sampling. **Note:** Settings should not be changed.

- All air sampling devices will be calibrated to ensure accurate sample volumes are collected. The frequency of calibration will not exceed one (1) year.

7.1.2 Attach the air sampling head to the intake of the low volume sample pump or to the Tygon tubing of the lapel sampler.

7.1.3 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.

7.1.4 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 a distance of 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 workers belt.

7.2 Collecting the sample

7.2.1 When the sample head with filter is in position, start the low volume or high volume sample pump and adjust the flow rate to the highest practical flow rate that can be maintained without flow rate fluctuations. BZ/lapel air samplers are not to be adjusted but rather be left at the calibration setting of 4 LPM following manufacturer maximum recommended flow rates.

7.2.2 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.

7.2.3 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.

7.2.4 Collect the sample for the maximum time possible, which represents the exposure encountered by the worker.

7.2.5 At the end of the collection period, note the flow rate of the sample pump and record this flow rate and the time, which the sampling stopped on the Air Sample Data Sheet. Collection times must be sufficient to achieve required MDA/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).

7.2.1 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.

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

7.2.3 Determine the average sample flow rate by adding the initial sample flow rate and the final sample flow rate and dividing by 2. Record the average flow sample flow rate in the space provided on the Air Sample Data Sheet.

7.2.4 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.

7.3 Determining Minimum Detectable Activity (MDA) – During calculations or air concentrations in the following sections, the MDA for each analysis is calculated to determine the statistical significance of the calculated air concentrations.

7.3.1 For each air concentration calculation (alpha and beta) in the following sections, calculate the MDA using the following formula:

$$MDA\ in\ \mu Ci/cm^3 = \frac{\frac{k_\alpha^2}{T_{s+b}} + 2\left[k_\alpha\right]\sqrt{\frac{R_b}{T_b} + \frac{R_b}{T_{s+b}}}}{(2.22\times10^6)(E)(V)}$$

Where:

E = Counter efficiency in CPM/DPM

R_b = Background Count Rate in CPM

T_b = Background Counting Time in Minutes

T_{s+b} = 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%

7.3.2 If the MDA is larger than 10% of the DAC, 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 Data Sheet.

7.4 Initial Air Sample Analysis – The initial analysis of air samples provides the air concentrations for short-lived radionuclides and a first estimate of the long-lived air concentrations. 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.

7.4.1 Air particulate samples are to be analyzed, at a minimum, for gross alpha and gross beta activity using a Ludlum Model 2929 Dual Channel Scaler or equivalent.

7.4.2 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).

7.4.3 Record the alpha and beta sample DPM results in the Air Sample Data Sheet.

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

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

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

Note: If air sample concentration is greater than 10% of the DAC value, notify the RSO or duly authorized representative for further instructions.

7.4.6 If the air concentration is less than 10% of the most restrictive DAC, no further analysis of the air sample is required. If the air concentration exceeds 10% of the DAC concentration, proceed with the analysis in section 7.5.

7.5 Air sample analysis for long-lived radionuclides – This analysis allows for decay of naturally occurring radionuclides and provides for correcting air concentrations for naturally occurring radionuclides.

7.5.1 Particulate samples will be analyzed for gross alpha and gross beta following a 30-minute delay to account for radon decay, and again at 4 hours, if necessary, to allow for further decay using a Ludlum Model 2929 Dual Channel Scaler or equivalent.

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

7.5.3 Record the alpha and beta sample DPM results in the Air Sample Data Sheet.

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

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

7.5.5 Enter the alpha and beta air concentrations, on the Air Sample Data Sheet, in the space provided. If the 30-minute decay air concentration is below 10% of the DAC, no further analysis is required.

7.5.6 If the 30-minute air concentration is above 10% of the DAC value, recount the air sample following 4 hours of decay from the time the sample was stopped. Calculate the air concentration using the formula in step 7.5.4 and record the air concentrations in the space provided for the 4-hour decay air concentration on the Air Sample Data Sheet.

- If the 4-hour air concentration is below 10% of the DAC value, no further analysis is required.
- If the concentrations are above 10% of the DAC value, recount after 24 hours and document on the Air Sample Data Sheet.
- If the air concentrations exceed 10% of the DAC values, notify the RSO or duly authorized representative for further instructions. Save the air sample for possible further analysis.
- For air samples, which exceed 10% of the DAC values, an exposure is assigned to the workers residing in the area where the sample was taken.

7.6 Assignment of DAC-hour exposures to workers

7.6.1 For air samples which exceed 10% of the DAC values, calculate the workers DAC-hour exposure using the following formula:

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

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.

7.6.2 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 duly authorized representative for the protection factor used to adjust DAC-hour exposure.

8.0 REFERENCES

- Title 10, Code of Federal Regulations, Part 20, *Standards for Protection Against Radiation*.
- Radiation Safety Program, Cabrera Services Inc., Manual
- OP-021, *Alpha-Beta Sample Counting Instrumentation*, Cabrera Services Inc., Operating Procedure
- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure
- U.S. Nuclear Regulatory Commission, *Air Sampling in the Workplace*, Regulatory Guide 8.25, (1992).
- U.S. Nuclear Regulatory Commission, Consolidated Guidance About Material Licenses, *Vol.11 - Program-Specific Guidance About Licenses of Broad Scope*, NUREG-1556, (1999).
- CABRERA Effluent Monitoring Work Instruction, Pohakuloa Training Center, PTA-W1-001, 02 December 2010

9.0 REQUIRED RECORDS

- Air Sample Data Sheet (written or electronic)
- Daily Air Sample Record (written or electronic)

10.0 ATTACHMENTS

- Attachment A – Air Sample Data Sheet
- Attachment B – Daily Air Sample Record
- Attachment C – Contamination Limits

Attachment A

Air Sample Data Sheet

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

Daily Air Sample Record

Daily Air Sample Record

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

Attachment C

Contamination Limits

Contamination Limits from Table 1 of RSP

RADIONUCLIDE	ALLOWABLE SURFACE CONTAMINATION (DPM/100 CM^2)	
	REMOVABLE	FIXED + REMOVABLE
Transuranics, Ra-226, Ra-228, Th-230, Pa-231, Ac-227, I-125, I-129	20	100
Th-Natural, Th-232, Sr-90, Ra-223 Ra-224, U-232, I-126, I-131, I-133	200	1000
U-Natural, U-235, U-238, and associated Decay products	1000	5000
Beta-Gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	1000	5000

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

UNCONDITIONAL RELEASE OF MATERIALS FROM RADIOLOGICAL CONTROL AREA

OP-004

REVISION 2.0

Reviewed by:

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

Approved by:

Henry Siegrist

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

1.0 PURPOSE

The purpose of this procedure is to specify requirements for releasing surface contaminated material and equipment from Radiological Controlled Areas (RCA) under Cabrera Services Inc (CABRERA) control. This procedure sets forth the requirements for release of these items from controlled areas at CABRERA project field sites.

2.0 APPLICABILITY

2.1 This procedure provides instructions for CABRERA field personnel for performing release surveys of items controlled as contaminated or potentially contaminated with radioactive materials.

2.2 Using these survey techniques, the procedure ensures that materials released from contaminated or potentially contaminated areas will meet the release criteria applicable to the license conditions, facility requirements, or in specified regulations/guidance required by regulatory agencies of the federal or state government.

2.3 Release of large items, such as waste containers used to ship bulk quantities of soil and waste for disposal, are further covered by the CABRERA procedure OP-001, *Radiological Surveys*.

2.4 Sealed check sources having activity less than listed in Schedule B, of 10 CFR 30.71 (Title 10 of the Code of Federal Regulations Part 30.71), are considered exempt quantities and are not covered by this procedure.

3.0 DEFINITIONS AND ABBREVIATIONS

3.1 Activity – The rate of disintegration (transformation) or decay of radioactive material. The units of activity for the purpose of this procedure are Becquerel (Bq) or microCuries (μCi).

3.2 Contamination – Deposition of radioactive material in any place where it is not desired. Contamination may be due to the presence of alpha particle, beta particle or gamma ray emitting radionuclides.

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

3.4 Fixed Contamination – Radioactive contamination that is not readily removed from a surface, by applying light to moderate pressure, when wiping with a paper or cloth disk smear or Masslinn.

3.5 Minimum Detectable Activity (MDA) – For purposes of this procedure, MDA 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 Release for Unconditional Use – A level of radioactive material below which an item/object is determined to be acceptable for use without restrictions. Under normal circumstances, authorized limits for residual radioactive material are set equal to, or below, the values specified in NRC Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*.

3.7 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.

3.8 Survey Exempt Materials – Prior to leaving a RCA, all materials that exit must be surveyed. Items exempt from this rule are those that remain enclosed, in a sealed container, while in the RCA. Although its contents are exempt, the container must still be surveyed. For example, if a flashlight is used in a RCA, the exterior of the flashlight must be surveyed. However, the batteries are considered survey exempt materials if they were kept enclosed, in the sealed casing, and did not contact radiological material.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

4.1.1 Ensure that all instruments used to perform release surveys are operated in accordance with their respective operating procedure or the manufacturer's operating manual.

4.1.2 Large area smears (LAS) may be used to augment (but not replace) the 100 square centimeters (cm^2) smear survey. The LAS may be counted with the Ludlum Model-3 and 44-9 probe or Ludlum 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 A document package, for equipment/items that are unconditionally released, should include the following:

- Radiological Survey Form for radiation or contamination surveys.
- Unconditional Release of Equipment and Items Log.
- Daily instrument quality control (QC).
- Any calculations or templates used to determine the total and transferable surface contamination levels.

4.1.4 The release documents should contain the following information:

- Completed Radiological Survey Forms with the date of the survey.
- Description or identification of the item(s).
- The release approval of the Radiation Safety Officer (RSO) or their duly authorized representative.

4.1.5 Ensure that radiation/contamination surveys are performed in accordance with OP-001, *Radiological Surveys*.

4.1.6 Ensure that items identified as radioactive, during the release survey, are controlled in accordance with OP-019, *Radiological Posting*.

4.1.7 Ensure that personnel performing release surveys are logged in on a Radiation Work Permit, in accordance with AP-012, *Radiation Work Permits* (if applicable).

4.1.8 Ensure that instruments used for release surveys are within current calibration and will have a response check performed daily, or before use, in accordance with the instrument's operating procedure or manufacturer's operating manual.

4.1.9 Ensure that items presented for release are direct scanned in an area of low background.

4.2 Limitations

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

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

4.2.3 During direct radiation scans, the meter probe will be held at the proper distance with allowance for the meter reading to stabilize.

4.2.4 If an instrument used to perform release surveys fails any operational checks, it will be removed from service. Data collected, during the period of instrument failure, must be evaluated by the RSO or duly authorized representative.

4.3 Requirements

4.3.1 Audible response instruments must be used during direct scan surveys.

4.3.2 Instrumentation used for surveys will be checked each day, prior to use, with standards and verified to have current valid calibration.

4.3.3 When releasing a large volume of materials, a program may be established, under the discretion of the RSO or their duly authorized

representative, to ensure by second check that no radioactive material has been released to the public or the environment.

4.3.4 Surveys performed for the release of material will be documented on a Radiation and Contamination Survey and/or on an Unconditional Release of Equipment or Items Survey (see Attachment A).

4.3.5 The Radiation Protection Technician (RPT) performing the survey will review the Unconditional Release of Equipment and Items Log and all other applicable forms for accuracy and completeness.

4.3.6 Entries on Unconditional Release of Equipment and Items Log and all other pertinent forms must be dated and initialed, by the RPT performing the survey, to be valid.

5.0 EQUIPMENT

There is no special equipment required for this procedure.

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) – Responsible for ensuring that personnel assigned the task of surveying materials know this procedure, are adequately trained in its use, and have ready access to a copy.

6.2 Radiation Safety Officer (RSO) – Responsible for verifying that personnel are trained in the use of contamination survey meters, described in this procedure, and comply with procedure requirements. The RSO or their duly authorized representative (a) reviews all applicable forms for accuracy and completeness and (b) signs/dates the release approval documentation.

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 Technician (RPT) – Responsible for performing the surveys described in this procedure. The RPT performing the survey will review the Unconditional Release of Equipment and Items Log, and all other applicable forms, for accuracy and completeness. The RPT ensures the use of the most current, approved version of these documents.

7.0 PROCEDURE

7.1 Release Limits for Gross Activity (Unknown Isotopes)

Exhibit 1: Release limits from NRC Regulatory Guide 1.86

EMISSION	REMOVABLE (dpm/100 $cm^{2)1}$	TOTAL[2] (dpm/100 $cm^{2)}$
Alpha	20	100
Beta-Gamma	200	1000

[1] dpm/100 cm^2 = disintegrations per minute per 100 square centimeters
[2] fixed and removable

Note: If **all** of the constituents of the contamination are known **and** documented on the release documents, the applicable release limits are derived from Table 1 of the NRC Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*.

7.2 Inaccessible Surfaces

7.2.1 Items with inaccessible internal surfaces should be disassembled, as completely as possible, to facilitate release surveys. Items with inaccessible surfaces will not be unconditionally released unless evaluated by the RSO, the duly authorized representative, or a designated evaluator who must authorize and document the release.

7.2.2 The following guidance will be used when performing evaluations for equipment/items with inaccessible surfaces:

- Review the history of the item and where it was used.
- Review the actual release survey.
- Review the determination of the radiological conditions in the area the item has been used or stored.
- Consider the use of gamma radiation sensitive detectors such as Sodium Iodide (Thallium activated) [NaI(Tl)] or its equivalent. **Note:** These detectors may indicate internal contamination that a beta sensitive detector may not detect. This is due to the beta detector's lack of sensitivity to photon emissions, as well as the inability of beta emissions to penetrate through many surfaces.

7.2.3 Equipment, which has internal combustion engines, is not readily disassembled. Airborne data, equipment running time, and survey of motor air filters provide sufficient information to make a determination of potential internal contamination.

7.3 Materials considered dangerous, fragile, or not readily smearable – due to their physical or chemical nature – will not be unconditionally released unless evaluated, on a case-by-case basis, in a manner consistent with Section 7.2.2. Evaluation for release will be performed **only** by a designated evaluator who must authorize and document the release.

7.4 Survey Exempt Materials

Writing implements, flashlights and other small personal items brought into and used in contaminated areas will be surveyed by frisking, when leaving a controlled area, in the same manner as a personnel whole body frisk. Items defined as survey exempt materials (see Section 3.8) do not require frisking to be released.

7.5 Survey and Action Levels

7.5.1 Upon receipt of an item presented for release, attempt to determine the history:

- Its purpose,
- Current and past use,
- Location(s) the item was used or stored (contaminated or airborne area),
- Whether it was ever used for work with radioactive material or used in an area where radioactive material was used or stored.

Note: This knowledge of the item history should provide the surveyor with information helpful in performing the release survey.

7.5.2 Perform radiological surveys using protective clothing (e.g., gloves) if loose contamination is suspected, in accordance with OP-001.

- Perform a direct scan of all accessible areas of the item and determine the total and transferable (loose) radioactive material present, in accordance with OP-001.
- If the presence of radioactive contamination is indicated at levels exceeding Regulatory Guide 1.86 (or Section 7.1 above for unknown isotopes), the item or material is considered contaminated and will not be released until it is decontaminated. Control these materials in accordance with OP-019.

Note: Items presented for release will be direct scanned in an area of low background ($\leq$ 100 counts per minute) when practical. The RPTs performing release surveys will determine if the background is acceptable for direct scan of the item.

7.5.3 If the direct radiation scan indicates radioactive material on the surface of the item is less than the limits of release for total activity, proceed to 7.5.5.

7.5.4 If the scan indicates radioactive material on the surface is greater than regulatory limits for total activity, the item cannot be unconditionally released until it is decontaminated.

7.5.5 Perform sufficient 100 cm^2 smears on the item to ensure that the contamination survey is representative of the item's surface area. OP-001 provides further guidance on large waste containers (also refer to Section 4.1.2).

7.5.6 Count and document the smear results in compliance with OP-001 and OP-021, *Alpha-Beta Counting Instrumentation*.

- Record smear(s) data on the radiological Survey Form.
- Determine transferable contamination levels.

- If the smear results indicate transferable activity below the release limits, proceed to step 7.5.7.
- If the smear results indicate transferable activity above the release limits, the item cannot be released until it is decontaminated.

7.5.7 If the item has internal or inaccessible surfaces, CABRERA personnel will disassemble the item and either (a) repeat Steps 7.5.2 through 7.5.6 or (b) have the item evaluated for release by a designated evaluator who has sufficient knowledge to perform radiological surveys on items presenting difficult geometries.

7.5.8 If the item meets the release limits or is evaluated as meeting the unconditional release criteria, complete the Unconditional Release of Equipment and Items Log. The RSO or their duly authorized representative should review the release documents and approve release before allowing an item(s) to leave the controlled area.

7.5.9 If items are identified as radioactive during the release survey, contact the RSO or their duly authorized representative as soon as possible.

7.5.10 Any vehicle or container, with removable contamination exceeding the Department of Transportation limits, will be brought to the attention of the RSO or their duly authorized representative for release or acceptance approval, as appropriate.

7.5.11 Dose rate surveys, which exceed 0.2 micro-Roentgens per hour, will be brought to the attention of the RSO or their duly authorized representative for release or acceptance approval, as appropriate.

7.6 The results of either radiation or contamination surveys will be documented on a Radiological Survey Forms.

8.0 REFERENCES

- Title 10, Code of Federal Regulations, Part 20, *Standards for Protection Against Radiation*.
- AP-010, *Personnel Protective Equipment Used Within Radiological Control Areas*, Cabrera Services Inc., Operating Procedure
- AP-012, *Radiation Work Permits*, Cabrera Services Inc., Operating Procedure
- AP-016, *Radioactive Material Tracking*, Cabrera Services Inc., Operating Procedure
- OP-001, *Radiological Surveys*, Cabrera Services Inc., Operating Procedure
- OP-009, *Use and Control of Radioactive Check Sources*, 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-023, *Operation of Micro-R Survey Meters*, Cabrera Services Inc., Operating Procedure
- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure
- U.S. Nuclear Regulatory Commission, Consolidated Guidance About Material Licenses, *Vol.11 - Program-Specific Guidance About Licenses of Broad Scope*, NUREG-1556, (1999).
- U.S. Nuclear Regulatory Commission, *Termination of Operating Licenses for Nuclear Reactors*. Regulatory Guide 1.86, (1974).

9.0 REQUIRED RECORDS

- Unconditional Release of Equipment and Items Log
- Radiation and contamination surveys on Radiological Survey Forms
- Daily instrument QC documentation (e.g., logs/forms)
- Any calculations or templates used to determine the total and transferable surface contamination levels.

10.0 ATTACHMENTS

Attachment A - Unconditional Release of Equipment and Items Log

Attachment A

Unconditional Release of Equipment and Items Log

UNCONDITIONAL RELEASE OF EQUIPMENT AND ITEMS LOG

Project Name _____Project Number_____

Item/ Equipment Released	Comments	Survey #	Surveyor Initials	Date

Reviewed By: _____ Date: _____

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

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 · ENVIRONMENTAL · REMEDIATION

RADIATION SAFETY PROCEDURE

FOR

CHAIN-OF-CUSTODY

OP-008

REVISION 1

Approved by: Henry Siegrist Date: 6/1/2006

Henry Siegrist, CHP, PE, Corporate Health Physicist

Approved by: Dave Watters Date: 6/1/2006

Dave Watters, CHP, Senior Vice President, Operations

1.0 PURPOSE

This procedure provides the methods Cabrera Services, Inc. (CABRERA) personnel shall utilize to transfer samples collected for characterization and/or final status surveys to a certified laboratory for analysis. Adherence to this procedure will provide assurance that appropriate analyses are requested, and that proper association between sample ID, sample location, and other pertinent sample parameters are documented and tracked by a known organization.

2.0 APPLICABILITY

This procedure will be used at all CABRERA work sites that require sample analysis to facilitate collection of data to be used in the official evaluation of the radionuclide or hazardous material content of the sample.

3.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

3.1 Precautions

3.1.1 Samples sent to an offsite analytical laboratory for analysis shall be returned to the site after processing for disposal if this is the condition of the laboratory contract. There may be occasions where the laboratory will hold and/or dispose of the samples.

3.1.2 Samples containing licensed radioactive material may only be sent to laboratories approved to handle such samples. Personnel shall use caution to assure sample radioactivity does not exceed the laboratory's license quantities.

3.2 Limitations

3.2.1 Personnel shall contact the contracted analytical laboratory to verify if they have their own required chain-of-custody. If the laboratory has its own, then personnel shall utilize their provided form, not the one used in this operating procedure.

3.3 Requirements

3.3.1 The chain-of-custody provided as an attachment to this procedure is based on an electronic CABRERA template. The version included in this procedure is provided as an example, not for use at a worksite. Personnel who use it shall ensure that they are using the most updated electronic template.

4.0 REFERENCES

- CABRERA Radiation Safety Program (RSP)
- AP-001 Record Retention

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Custody Seal - Custody seals are tamper-indicating devices. They record if access has occurred, they are not meant to resist it.

6.0 EQUIPMENT

Custody seals

7.0 RESPONSIBILITIES

7.1 Corporate Radiation Safety Officer/Health Physicist (RSO or Corp. HP) - The RSO or Corp. HP shall ensure that personnel who work with radioactive material are trained, and have an adequate understanding in the use of this procedure.

7.2 Health Physics Technicians (HPT) - The HPT are responsible for the control of radioactive material, coverage of radiation workers, and general safety protection. The HPT are responsible for knowing and complying with this procedure.

7.3 Project Manager (PM) - The PM is responsible for the radiological safety of all personnel onsite, ensuring that if they work in radiologically controlled areas, that they are familiar with this procedure, adequately trained in its use, and have access to a copy of procedures.

7.4 Sample Collector - Sample collectors are responsible for following the SRSO's instructions to ensure compliance with this procedure.

7.5 Site Radiation Safety Officer (SRSO) - The SRSO acts as the RSO's and Corp HP's duly authorized representative for radiological issues when neither are onsite. The SRSO shall be onsite when work is in progress and shall perform the requirements established in this procedure, and ensure that they are implemented during field assignments.

8.0 INSTRUCTIONS

8.1 General Instructions

8.1.1 The sample collector shall initiate a chain-of-custody form by filling in the requested information. Personnel may utilize the "Chain-of-Custody Checklist" (supplied in Attachment OP-008-01) to verify they

have completed CABRERA's chain-of-custody (supplied in Attachment OP-008-02) completely.

8.1.2 Proper chain-of-custody is maintained when the sample is controlled under the direct surveillance of an individual; in a controlled access facility, or the sample is in a tamper-resistant container.

8.1.3 If the sample is to be transported by any means other than hand delivered by the custodial individual, custody seals shall be used.

8.1.4 Upon transfer of the samples to another individual, that individual shall sign as recipient. A copy of the chain-of-custody form shall be maintained for record keeping purposes while the original will remain with the sample.

8.1.5 Upon arrival of the sample at the laboratory, the laboratory recipient shall inspect the sample for signs of tampering. If indication of tampering is noted, the laboratory shall notify site personnel who may need to collect another sample as conditions merit.

8.1.6 Once the sample is in the custody of the laboratory, it shall be maintained in accordance with the laboratory's chain-of-custody and quality assurance procedures.

8.2 Recordkeeping

8.2.1 Information shall be documented clearly, neatly, accurately, and concisely, and prepared in dark, waterproof ink. Data shall not be obliterated by erasing, with whiteout, or by any other means. To make a correction, a single line shall be struck through the error, and the corrector shall initial and date the line.

8.2.2 The HPT or designee shall review applicable forms for accuracy and completeness, and date and initial entries to validate the survey.

8.2.3 Records shall be maintained in accordance with "Record Retention" (AP-001).

9.0 ATTACHMENTS

- OP-008-01 CABRERA Chain-of-Custody Checklist
- OP-008-02 Chain-of-Custody/Analysis Record

OP-008-01 - CABRERA Chain-of-Custody Checklist

REQUIRED INFORMATION	DESCRIPTION AND INSTRUCTIONS	COMPLETED?
Page: of		
Project #:		
Lab Quote #:	Supplied by analytical laboratory	
COC #:		
PO #:		
Project/Site Name:		
Collected By:	Sample collectors	
Send Results to:	Project manager for site	
Custody Seal #:	As applicable, some laboratories do not require this	
Laboratory:	Complete analytical laboratory name, address, phone #, and fax #	
Should this sample be considered:	Check box to appropriate sample ID as to whether the sample should be considered radioactive and/or TSCA regulated	
Preservative Type:	Refer to footnote 5, and fill in appropriate information	
Sample Analysis Requested:	Refer to footnote 4 and fill in appropriate information, list the appropriate number of sample containers in the appropriate Sample ID row	
Sample ID	List each sample ID being shipped under this Chain-of-Custody	
Date Collected	Document date sample was collected in mm-dd-yy format	
Time Collected	Document time sample was collected in military time (hhmm)	
QC Code	Refer to footnote 1, and fill in appropriate information	
Field Filtered	Refer to footnote 2, and fill in appropriate information	
Matrix Code	Refer to footnote 3 , and fill in appropriate information	
Comments:	List any comments regarding samples	
Requested Turnaround Time:	Provided by project manager	
Fax Results:	Circle Yes or No	
Email Results, when available to:	Enter PM's email address	
Remarks:	List any remarks	
Chain-of-Custody Signatures	Sign under relinquished by and document date and time when relinquishing shipping container to shipper	
Sample Shipping and Delivery Details	Fill in the laboratory PM, method of shipment (i.e., FedEx, UPS, etc.), date shipped, and airbill #.	

OP-008-02 - Chain-of-Custody/Analysis Record

Page: of	**CABRERA Chain-of-Custody and Analytical Request**	Laboratory:
Project #:		Address:
Lab Quote #:		
COC #:		Phone #:
PO #:		Fax #:

Client Name: Cabrera Services, Inc.	Custody Seal #:						Should this sample be considered:		Preservative Type (5)												**Comments**	
Address: 473 Silver Lane East Hartford, CT 06118	Phone #: (860) 569-0095 Fax #: (860) 569-0277																				Note: Extra sample is required for sample-specific QC	
Project/Site Name:							Radioactive	TSCA Regulated	Sample Analysis Requested (4) (Fill in the number of containers for each test)													
Collected by:	Send Results to:																					
Sample ID	Date Collected (mm-dd-yy)	Time Collected (Military) (hhmm)	QC Code(1)	Field Filtered(2)	Matrix Code(3)																	

Requested Turnaround Time: Normal: __ Rush: ____ Specify: ____ (subject to surcharge) | Fax Results: Yes / No | Email Results, when available to:

***Remarks*:** *Are there any known hazards applicable to these samples? If so, please list:*

Chain-of-Custody Signatures					**Sample Shipping and Delivery Details**	
Relinquished By (Signature)	Date	Time	Received By (Signature)	Date Time	Laboratory PM:	
1			1		Method of Shipment:	Date Shipped:
2			2		Airbill #:	
3			3		Airbill #:	

1.)	QC Codes: **N**: Normal Sample; **TB**: Trip Blank; **FD**: Field Duplicate; **EB**: Equipment Blank; **MS**: Matrix Spike Sample; **MSD**: Matrix Spike Duplicate Sample; **G**: Grab; **C**: Composite	***For Lab Receiving Use Only***
2.)	Field Filtered: Only applicable to liquid matrices. Answer **Y** if the sample was field filtered or **N** if the sample was not field filtered.	*Custody Seal Intact?*
3.)	Matrix Code: **DW**: Drinking Water; **GW**: Groundwater; **SW**: Surface Water; **SO**: Soil; **SD**: Sediment; **SL**: Sludge; **SOW**: Solid Waste; **O**: Oil; **F**: Filter; **P**: Wipe; **U**: Urine	*YES NO*
4.)	Sample Analysis Requested: Analytical method requested (i.e., **8260B**, **6010B/7470A**) and number of containers provided for each analysis	*Cooler Temp: _____ ˚C*
5.)	Preservative Type: **Hcl**: Hydrochloric Acid; **NI**: Nitric Acid; **SH**: Sulfuric Acid; **AA**: Ascorbic Acid; **HX**: Hexane; **ST**: Sodium Thiosulfate; **C**: Cool; *If **no preservative** is added, then leave the field blank.*	

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

USE AND CONTROL OF RADIOACTIVE SOURCES

OP-009

REVISION 1.0

Prepared/Reviewed by:

David Wunsch, Quality Assurance Manager — 4/12/2013 — Date

Approved by:

Henry Siegrist

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

1.0 PURPOSE

This procedure describes methods for control of instrument check sources and the methods used by Cabrera Services Inc. (CABRERA) to evaluate sources for the potential of leaking radioactive material. These sources are used to ensure proper radiation detection instrument operation.

2.0 APPLICABILITY

2.1 This procedure will be used by Cabrera personnel for use and control of radioactive sources used for portable radiation detectors and will also be used when leak testing licensed radioactive sources, as defined in the Cabrera NRC License, and other RSO requested source leak testing.

2.2 Adherence to this procedure will provide reasonable assurance that: personnel exposures will be below specified limits; sources will not be lost or misplaced; personnel will remain free of contamination; and, contamination will not be spread beyond any designated contaminated areas. In addition, it will provide a reasonable assurance that leak testing, of radioactive sources, meets the requirements of Title 10, Code of Federal Regulations, Part 20 (10 CFR 20) and Cabrera's NRC license.

3.0 DEFINITIONS

3.1 Restricted Area – An area, to which access is limited by the licensee, for protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted areas do not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

3.2 Leak Test – A survey technique used to determine the presence of removable activity from the surface of a sealed source.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

4.1.1 When performing a leak test on licensed-quantity sources, use specific license procedures.

4.1.2 If licensed-quantity sources are being inspected, the RSO or duly authorized representative will determine any additional precautions (e.g., finger rings, etc.).

4.1.3 Sealed sources of activity may exhibit high dose rates. Ensure that a thorough dose rate survey has been performed documented prior to beginning any leak test evaluation.

4.1.4 The window area of an alpha-beta detector may be covered with a thin window and may be easily punctured. Avoid surveying areas which have protruding fragments that may puncture the detector face. Remove the protruding fragments, if possible, before surveying. Upon removal of the leak test sample, analyze the sample away from the source. If the sample yields a high-count rate compared to background, assume the source to be leaking and provide appropriate controls to limit contamination spread.

4.2 Limitations

4.2.1 Storage location(s) of radioactive sources will be approved by the RSO, or duly authorized representative, for protection against loss, leakage, or dispersion by the effect of fire or water.

4.2.2 This procedure does not apply to pure gamma emitters not emitting alpha or beta particles – contact the RSO for guidance.

4.2.3 A Radiation Work Permit (RWP) must be generated for leak testing of non-exempt sources or sources exceeding contact dose rates of 100 mrem/hr gamma or 1,000 millirad/hr beta. For instructions on how to generate an RWP refer to AP-012.

4.3 Requirements

4.3.1 Individual source quantities shall not result in exceeding license limits.

4.3.2 The methods specified in this procedure will be reviewed annually to ensure compliance with the requirements of the CABRERA NRC License to measure leakage from sealed radioactive sources.

4.3.3 The leak test shall be capable of detecting the presence of 0.005 microcuries of removable activity to comply with the NRC requirements of the CABRERA Radioactive Material License.

4.3.4 Ensure accountability and direct control of sources at all times when unlocked and in use. Minimize the number of people in the area of the source during the leak test to reduce exposure and maintain work areas as low as is reasonably achievable (ALARA). If high radiation area controls are necessary, the source must either be locked or guarded.

4.3.5 Only qualified CABRERA Radiation Worker personnel may use or have possession of CABRERA radioactive sources.

4.3.6 Only CABRERA NRC Material License Authorized Users or CABRERA Designees as provided for by written authorization may provide leak tests on licensed radioactive sources.

4.3.7 The quality of leak test analyses is dependent upon the quality of the wipe and the quality of analysis. Periodic evaluation of the process and

analysis methods shall be conducted to ensure appropriate methods are used and this procedure is followed.

4.3.8 The RSO or duly authorized representative shall review completed forms for accuracy and completeness.

5.0 EQUIPMENT

- Ludlum 2929 or equivalent
- Remote smear handling assembly
- Liquid cleaner (if recommended by source manufacturer)
- Smears
- Portable radiation detection equipment
- Calibration sources

6.0 RESPONSIBILITIES

6.1 Radiation Safety Officer (RSO) – Responsible for verifying that personnel comply with this procedure and are trained with respect to radioactive source use, as described in this procedure. The RSO ensures that CABRERA personnel performing this procedure are qualified by training and experience to perform its requirements.

6.2 Site Radiation Safety Lead (SRSL) – During field assignments, the SRSL is responsible for ensuring that this procedure is properly implemented. When the RSO is not on site, the SRSL will act as the RSO's duly authorized representative for radiological issues. The CABRERA NRC Material License Authorized User or Designee conducting leak tests of licensed radioactive sealed sources is responsible to comply with the provisions of this procedure

6.3 Radiation Protection Technician (RPT) – Responsible for the control and use of exempt radioactive check sources.

7.0 PROCEDURE

7.1 Action Levels

7.1.1 Source Inventory

- A physical source Inventory is conducted at intervals not exceeding six months. The RSO or duly authorized representative shall be notified immediately if it has been determined that a source is missing and an immediate search shall be conducted. Loss of licensed radioactive sources may require NRC notification by the RSO.

- The RSO shall be immediately notified of any new radioactive sources controlled or purchased by CABRERA projects. Such sources include both exempt and non-exempt sources.

7.1.2 Source Leak Tests

- Sealed sources shall be tested for leakage at intervals not to exceed that specified on the certificate of registration issued by the NRC under 10 CFR 32.210 or equivalent regulations of an Agreement State.
- Sealed sources designed to primarily emit alpha particles shall be tested for leakage at intervals not to exceed 3 months.
- In the absence of a certificate from a transferor indicating that a leak test has been made within the interval specified by the NRC, a leak test will be performed by CABRERA personnel prior to putting a non-exempt source into use.
- Sealed sources need not be tested if they contain only tritium; only a radioactive gas; have a half-life of less than 30 days; or contain no more than 100 microcuries of beta-gamma or 10 microcuries of alpha emitting material. Sealed sources not being used and that are in storage do not need a leak test. However a leak test must be performed prior to transferring the source to another person. No source shall go untested for a period of more than 10 years.

7.1.3 Source Leakage

If a source is suspected to have lost its integrity, the RSO or duly authorized representative shall be notified immediately and a leak test shall be performed.

7.1.4 Storage Area Radiation Levels

Radiation levels shall be maintained at less than 2 millirem per hour (mrem/hr) on any accessible surface where the radioactive sources are stored. Notify the RSO or duly authorized representative if radiation levels exceed 2 mrem/hr.

7.2 Inventory List

The inventory list will be reviewed/updated at least once every six months, or whenever a new source is received or a source is disposed of to ensure inventory records are updated. Prior to disposing of a source, approval should be obtained from CABRERA's Corporate RSO. The results shall be recorded on the Source Inventory form (Attachment A), or equivalent, and shall be retained in the project files as well within the corporate source file for a period of not less than five years.

7.3 Storage

Radioactive sources and licensed radioactive sources will be stored in fire resistant containers when not in use. Such containers will be used at the worksite and for routine storage of the sources at CABRERA offices.

7.4 Leak Test Initial Preparations

7.4.1 Select a work area free of radioactive contamination to conduct the leak test.

7.4.2 Select instruments that have a Minimum Detectable Activity (MDA) capable of detecting at least 0.005 microcuries (μCi) of the radionuclide of concern.

7.4.3 If a wet wipe test is anticipated, prepare distilled water in a container, as appropriate, for the source being tested. Specific solutions may be mentioned in vendor documentation. If they are, use the solutions required by the vendor.

Caution: Do not directly smear unsealed sources, such as depleted uranium plates or fragile mylar windows covering sources. Rather, smear the areas around such sources, such as the holder and container or box holding such sources.

7.4.4 Inform the RSO or duly authorized representative of the source to be leak tested. The RSO or duly authorized representative will evaluate the test and may provide additional precautionary measures to ensure protection of people and equipment in the work area.

Caution: Do not touch or get extremely close to an exposed source of high specific activity. Sealed sources of high specific activity may cause high contact dose rates, resulting in high shallow dose equivalents to the extremities.

7.4.5 Use remote means to smear the outside surface of the source, using cloth or paper, for any high activity sources as described by the cautionary note. This smear will be the leak test sample that is analyzed for activity associated with a potentially leaking source. Wipe the outside surfaces of the source, up to and including, a total area of 100 cm^2.

7.4.6 Be cautious when handling leak test samples in order to prevent the spread of contamination, should the sample have loose radioactivity on it from a leaking source.

7.4.7 Minimize the time period conducting the leak test. In a well-planned test, the exposure time will be short.

7.4.8 If the source emits particle radiation, a very thin window will typically cover the radioactive material. Take special precautions to prevent damage to the window during leak testing.

7.4.9 Wear rubber or latex gloves when handling the leak test samples or equipment associated with the test.

7.5 Smear Analysis Using a Portable Instrumentation Probe

To maintain the calibrated detection efficiency, the detector probe must be held at the appropriate height, determined using calibration, when counting a leak test smear. This generally means ½ inches or less for alpha and low energy beta particles.

7.6 Smear Analysis Using Alpha-Beta Sample Counting Equipment

The leak test sample shall be analyzed by a method, which will ensure detection of at least 0.005 μCi of the radionuclide of interest. Existing CABRERA procedures and templates shall be used as practical to ensure appropriate analysis and documentation of results.

Note: If the activity estimation determines the leak test sample to be in excess of the leak test limit of 0.005 microcuries, then label the source as unusable to prevent further spread of activity. Conduct a detailed survey of the leak test work area to ensure that activity from the source has not spread beyond the capsule of the source and immediately contact the RSO.

7.7 Performing Leak Tests

7.7.1 Leak tests are performed on licensed radioactive sources received in the field prior to use. A leak test may also be performed on exempt quantity sealed sources, in the event a source is suspected of having a loss of encapsulation or other possible leakage.

7.7.2 A visual inspection of the source shall be made for physical damage. If an area of the source is noticeably damaged, perform the leak test in that area.

7.7.3 Determine the extent of source leakage by one of the following methods:

- Dry Wipe Test – This test will be performed on encapsulated sources or adjacent surfaces of plated or foil sources. The sources shall be wiped with a dry disc smear applying moderate pressure. (**Note**: Never wipe the surface of a plated or foil source.) Removal of any radioactive materials from the source or adjacent surfaces (i.e., source leakage) will be determined by counting the filter paper with appropriate instrumentation.
- Wet Wipe Test – This test will be performed on encapsulated sources only. The entire surface of the source shall be wiped with a disc smear moistened with distilled water, applying moderate pressure. Removal of any radioactive material from the source will be determined by counting the filter paper with appropriate instrumentation after the filter paper has dried out.

7.7.4 When any contamination or leak test reveals the presence of 0.005 μCi or greater of removable contamination, the source shall be retested.

The source will be either repaired, if possible, or disposed of as radioactive waste if the second test is unsatisfactory. The results of leak tests for the sources are recorded on the Source Leak Test Data Sheet (Attachment B) and shall be retained for a minimum of five years.

7.8 Source Storage Area Survey

The on-contact radiation level exterior to the location where the sources are stored shall be maintained at less than 2 mrem/hr on any accessible surface. A radiation survey of the storage location shall be performed at least quarterly and after the receipt of any additional sources.

8.0 REFERENCES

- AP-012, *Radiation Work Permits*, Cabrera Services Inc., Operating Procedure
- OP-001, *Radiological Surveys*, Cabrera Services Inc., Operating Procedure
- OP-020, *Operation of Contamination Survey Meters*, Cabrera Services Inc., Operating Procedure
- OP-021, *Alpha-Beta Sample Counting Instrumentation*, Cabrera Services Inc., Operating Procedure
- OP-022, *Operation of Ionization Chambers*, Cabrera Services Inc., Operating Procedure
- OP-023, *Operation of Micro-R Survey Meters,* Cabrera Services Inc., Operating Procedure
- OP-187, Records Management, Cabrera Services Inc., Operating Procedure
- U.S. Nuclear Regulatory Commission, Consolidated Guidance About Material Licenses, *Vol.11 - Program-Specific Guidance About Licenses of Broad Scope*, NUREG-1556, (1999).

9.0 REQUIRED RECORDS

9.1 The RSO or duly authorized representative prepares and maintains a source file which shall, at a minimum, consist of the following:

- Procurement history of each source, including copies of seller certification;
- Status change (damage, sale or transfer, disposal, or recalibration);
- Completed "Source Inventory" Form; and,
- Any other correspondence related to the sources.

9.2 Records of leak tests shall be kept in units of microCuries (uCi) and shall be maintained for five years.

10.0 ATTACHMENTS

Attachment A – Source Inventory

Attachment B – Sealed Source Leak Test Data Sheet

Attachment A
Source Inventory

SOURCE INVENTORY

Radionuclide	Undecayed Activity, μCi)	Serial Number/Bar Code	Date of Inventory	Location of Source	Performed by (initials) Date of inventory

Comments_____
_____
_____

Date Performed: _____ Reviewed by: _____

Attachment B
Source Leak Test Data Sheet

Source Leak Test Data Sheet

Source Information Source ID Number_____

Source Manufacturer: _____ Date of Assay: _____

Source Model Number: _____ Source Serial #_____

Activity of Source at Assay Date: _____ microcuries Source Today: _____ microcuries

Radionuclide name: _____ Half-life of radionuclide_____

Leak Test Sample Information

Location of Leak Test Work Area _____

Describe the method of leak testing: _____

Instrument/Serial Number: _____

Detector/Serial Number: _____ Calibration Due Date: _____

Alpha Detection Efficiency: _____ c/d Beta Detection Efficiency _____c/d

Background count time: _____ min.

Background alpha counts _____ Background beta counts _____

Alpha MDA: _____microcuries Beta MDA: _____microcuries
(MUST BE LESS THAN 0.005 microcuries)

Sample total alpha counts_____ Sample Total beta counts: _____

Sample count time: _____ min.

Leak test sample activity: _____microcuries alpha _____microcuries beta

Leak Test Result – Check all boxes that apply

- ❑ The leak test sample is in excess of the 0.005 microcuries alpha or beta limit
- ❑ The leak test sample is below the 0.005 microcuries limit
- ❑ The source has been controlled to prevent the spread of activity.

Source Leak Test Performed by: _____ Date: _____

Leak Test Analysis Conducted by: _____ Date: _____

Radiation Safety Officer: _____ Date: _____

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

DECONTAMINATION OF RADIOACTIVITY FROM EQUIPMENT AND TOOLS

OP-018

REVISION 1.0

Reviewed by:

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

Approved by:

Henry Siegrist

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

1.0 PURPOSE

This procedure establishes the requirements for decontamination of equipment, material, and tools used at Cabrera Services Inc., (CABRERA) field projects that become contaminated with radioactive material.

2.0 APPLICABILITY

This document applies to all CABRERA personnel involved in the decontamination. Each decontamination operation is unique; thus, this procedure provides general, effective decontamination techniques and guidelines to be used by CABRERA field personnel.

3.0 DEFINITIONS

3.1 Decontamination – The processes whereby contamination can be safely and effectively removed from equipment tools and materials.

3.2 Herculite – Herculite is a brand name plastic or polyethylene floor covering and containment material used for decontamination operations.

3.3 Material Safety Data Sheet (MSDS) – Sheets providing information and limitations about chemicals and products that is issued by the manufacturer.

3.4 Radiation Work Permit (RWP) – A document generated by Health Physics to provide:

- A description and scope of the work to be performed;
- Existing radiological conditions in the work area;
- Limitations placed upon the scope of work;
- Maximum radiological limits allowed;
- Measures to be employed to protect the worker(s); and
- Special instructions to workers and RPT personnel for the work to be performed.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

4.1.1 Decontamination of contaminated tools or equipment will be performed under the direction of an RPT. The RPT will provide direction in accordance with this procedure, and the RWP.

4.1.2 Decontamination activities will be performed within a controlled area.

4.1.3 Controls to contain the spread of loose contamination, during the decontamination activity, will be planned and established prior to the decontamination of equipment, material, and tools.

4.2 Limitations

4.2.1 This procedure may not be applicable or readily applied to decontaminating surfaces composed of porous materials such as wood or concrete. It is therefore not the preferred operating procedure for decontaminating building surfaces.

4.2.2 Protective clothing worn, by the personnel involved in decontamination activities, will be determined in accordance with the RWP.

4.2.3 Decontamination cleaning solvent/solutions will only be used in accordance with the directions and limitations listed on the manufacturer supplied MSDS.

4.2.4 Respiratory protection devices, required by the RWP for decontamination operations, will be selected and used in accordance with the provisions of CABRERA procedure AP-006.

4.3 Requirements

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

4.3.2 A pre-job briefing will be held to instruct RPTs and other personnel of the conditions of the RWP. All personnel performing work in the decontamination work area will sign the RWP prior to work.

4.3.3 Radiation and contamination surveys will be performed in accordance with the provisions of CABRERA procedure OP-001.

4.3.4 Release of equipment, materials, and tools from the decontamination work area will be performed in accordance with the provision of CABRERA procedure OP-004.

4.3.5 Operations conducted using this procedure will be reviewed for compliance at least annually.

5.0 EQUIPMENT

Appropriate Personal Protective Equipment (PPE) and decontamination equipment includes, but is not limited to:

- Herculite
- Decontamination rags
- Cleaning solutions

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) – Ensures that personnel assigned the task of decontamination know and understand this procedure, are adequately trained in its use, and have access to a copy.

6.2 Radiation Safety Officer (RSO) – Training of personnel in the decontamination techniques and performing radiation surveys described in this procedure; and ensures that technicians are qualified by training and experience to perform the requirements of this procedure.

6.3 Site Radiation Safety Lead (SRSL) – During field assignments, ensures that this procedure is properly 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 Technologist(s) (RPT) – Performing the surveys of decontaminated items, and ensuring that radioactive material is not released to the public or the environment.

7.0 PROCEDURE

7.1 Pre-Decontamination Preparation

7.1.1 The SRSL will initiate decontamination work instructions.

7.1.2 A radiological survey will be performed by an RPT on any item or object that is to be removed from a controlled area.

7.1.3 If radiological survey results indicate that an RWP is required for decontamination, the RSO or duly authorized representative will write the RWP in accordance with CABRERA procedure AP-012.

7.1.4 If a survey indicates that decontamination is required, the item should be bagged, wrapped, or contained under the direction of health physics staff. The RPT will label the item with all pertinent information.

7.1.5 The SRSL will approve or disapprove the decontamination operation based on conditions of the RWP and the cost effectiveness of the operation versus disposal costs.

7.2 Establishment of the Decontamination Work Area

7.2.1 The RSO or duly authorized representative and the SRSL will determine a location for the decontamination area.

7.2.2 Once a location has been established, the decontamination area will be set-up, by the RPT, under the direction of the SRSL.

7.2.3 The decontamination area should consist of the following:

- Covered (or equivalent) floor surfaces. A double layer of Herculite (or equivalent) may be laid on the floor at the direction of Health Physics staff.
- Covered (Herculite or equivalent) wall surfaces, if applicable.
- Engineering controls (HEPA ventilation, vacuum cleaners,

containment tent walls glove bags, etc.), if applicable.

- Engineering controls will be determined on the basis of the ALARA consideration section of the RWP.

Note: All possible engineering controls will be utilized when feasible to minimize the need for respiratory protection equipment.

- Use of safe, sturdy workstations with contamination resistant surfaces and tables that will support decontamination attempts on heavy pieces of equipment.
- Adequate supply of overhead light, adequate electrical/compressed air supply for the operation of electrical/pneumatic driven decontamination equipment.
- Adequate supply of CABRERA approved cleaning solutions and solvents along with an adequate supply of decontamination equipment, such as:
    - Light duty decontamination equipment such as paper wipes, paper towels, masselin towels, etc.
    - Medium to heavy-duty decontamination equipment such as scrub pads, wire brushes steel wool, files, sandpaper, etc.
    - Fully stocked hand tool kit for disassembly of contaminated equipment.
    - Radioactive material storage bags, stickers, etc.
    - Buckets, barrels or drums for the storage of contaminated liquids, sludges, or slurries, if applicable.
    - Blotter paper or sorbent, if applicable.
    - Approved absorbent material such as oil dry, if applicable.
- Storage drums/bags for the storage of contaminated protective clothing under direction of Health Physics staff.
- Proper surveillance instruments (air monitor/sampler, contamination monitor, friskers, dose rate meter, etc.) in accordance with the RWP.
- Adequate supply of personal protective clothing gloves respiratory equipment, etc.
- Step-Off or Double Step-Off Pad, in accordance with the provision of the RWP.
- A designated area, within the decontamination area, for the segregation of radioactive waste.

7.2.4 Once the decontamination area has been established and stocked for operation, the bagged and/or wrapped contaminated or controlled

equipment should be placed in the decontamination work area by the technician, under the direction of the SRSL and RPT. Contaminated or controlled items should always be escorted, under the direction of a RPT, to the decontamination area.

7.3 Decontamination

7.3.1 After the decontamination area has been posted, and area access controls established, all requirements of the RWP will be observed.

7.3.2 The preparation for decontamination of a particular tool, material, or piece of equipment will be performed, as follows:

- Position the wrapped item so that the written information on the label/wrapping is visible.

Note: Junior RPTs may operate survey instruments for decontamination monitoring purpose. RPTs will oversee Junior RPTs when survey instruments are in use.

CAUTION: Survey instruments to be used in a known or suspected contaminated area should be protected (wrapped in plastic, poly, etc.) against possible contamination before use.

- The RPTs will direct the removal of the item from the wrapping in such a manner (rolling plastic, poly, etc.) to control the spread of contamination.
- An item that is highly contaminated with loose contamination should be misted with an approved liquid such as demineralized water. The water vapor will wet down the particulate contamination and help prevent the possibility of generating airborne contamination.
- Once the item has been removed from the wrapping and has been properly positioned, discard the wrapping as radioactive waste.

7.3.3 The following decontamination techniques should be considered for the decontamination of equipment, materials, and tools:

- Any equipment with inaccessible areas will be dismantled so that all surfaces are accessible for decontamination and survey.
- Decontamination will be performed in a safe, effective manner.
- The RPT will be notified immediately if the job conditions change (e.g. suspected asbestos found, presence of mercury in a switch or a light bulb, a fluid leak, or any other special circumstances).
- An RPT (or qualified individual) will be assigned as a fire watch if any spark creating decontamination techniques (grinding, etc.) are used and there are combustible materials in the area. There will be

a dedicated fire extinguisher located within the decontamination work area.

- The decontamination area will remain organized and free of debris with the RPT enforcing the "clean-as-you-go" policy, whenever necessary.
- A HEPA vacuum cleaner may be used during the decontamination operation.

7.3.4 Smearable Contamination Removal

When the item is properly positioned for decontamination and the pre-survey has been completed, perform the following:

- Moisten the surface of the item with an approved liquid (e.g. demineralized water).
- Fold a paper or cloth wipe into sections, using one surface of the wipe gently wipe contamination off in one direction away from the user's body. This should reduce the possibility of personnel contamination.
- Re-fold the paper or cloth wipe so that a clean surface is available (this should prevent cross-contamination) and continue until item is ready for survey.
- For some materials, duct tape will effectively remove smearable contamination. Wrap the duct tape loosely around the gloved hand with the adhesive side out. Roll the tape over the contaminated area and re-survey.

7.3.5 Fixed Contamination Removal

There are many techniques that can be used to remove fixed contamination. The general idea is to remove the material, which is fixing the activity to the surface, or remove a very thin layer of the surface material. The techniques selected for a particular decontamination operation is at the discretion of the SRSL and the RPT. The techniques can be divided into the following categories:

- Light hand decontamination
- Abrasive hand decontamination
- Power tool decontamination
- Machine decontamination (use of abrasive bead blasters, grit blasters, high pressure water wash systems, etc.). The specific implementation of these techniques is not included within the scope of this procedure.
- Cleaning solutions/solvents (use of ultrasonic cleaners, acid baths,

electropolishing, etc.). The specific implementation of these techniques is not included within the scope of this procedure.

7.3.6 Light hand decontamination consists of using many of the same techniques as 7.3.4 of this procedure.

7.3.7 Abrasive hand decontamination will be performed in the following manner:

- Remove as much smearable contamination as possible.
- Moisten the surface of the item(s) to contain contamination.

CAUTION: Abrasive measure should only be applied to surfaces that are not critical for operation of devices, which must be restored to working condition. Abrasion of machined surfaces should be minimized if the device is intended to provide its designed operation.

- Use an abrasive cleaning tool (e.g. sandpaper, steel wool, steel brush, hand grinder, etc.) to loosen fixed contamination. Clean in one direction only and clean Away from the body to prevent personnel contamination.
- Continue to moisten the surface of the item(s) to contain contamination.
- Remove as much smearable contamination as possible.
- Re-survey.

7.3.8 Power tool decontamination will be performed in the following manner only as a last resort decontamination effort. The use of engineering controls must be used and must be under the guidance of the SRSL/RPT.

Note: When using power tools, always consider the potential of injury due to the hazards involved. Power tools will be used cautiously and in accordance with the manufacturer's recommendations.

Some of the electric power tools that can be used in decontamination operations are:

- Drills to drill out contaminated areas, to disassemble contaminated components and when used with grinding wheels or disks, may be used as an abrasive tool.
- Saws to separate contaminated pieces from clean pieces.
- Grinders to grind fixed contamination form surfaces.
- Electric screwdrivers used in the disassembly of component parts.

7.3.9 Power tool decontamination will be performed in the following manner:

- Using a spray bottle, moisten the surface of the item lightly to contain contamination.

CAUTION: Do not use electric power tools on a wet working surface. Keep liquids away from electric power tools.

- Whenever feasible a containment device (e.g. glove box or bag etc.) should be used to contain the spread of contamination when using power tools for decontamination operations.
- Use the power tool to remove fixed contamination. Clean in one direction only and clean away from the body to prevent personnel contamination.
- Re-survey.

7.4 Post-Decontamination

7.4.1 If the decontamination was successful, the technician will notify the RPT, who will perform a release survey in accordance with CABRERA procedure OP-004.

- If the item satisfies the criteria for release, as stated in OP-004, remove the item to a holding area for disposal and document results. When prepared for disposal, ensure compliance with the provisions of CABRERA procedures AP-014 and AP-013.
- If the item remains contaminated, attempt a second decontamination.
- If the item continues to be contaminated, attempt a third decontamination only at the direction of the RSO or duly authorized representative.

7.4.2 If an item cannot be effectively or economically decontaminated, the SRSL may direct the CABRERA work crew to volume-reduce (reduce to component parts) the equipment, material, or tools as much as possible. If the item is expendable, the individual parts may be surveyed and released in accordance with step 7.4.1.

7.4.3 If an item is volume-reduced to its component parts and decontamination is not feasible, and the item is not needed, the item parts will be considered radioactive waste. Radioactive waste is to be segregated into similar material for shipment purposes by the direction of the PM. The SRSL will direct the segregation of radioactive waste into the following categories:

- Steels, hard metals
- Wood

- Fiber products
- Paper
- Rubber
- Cloth (duct tape is considered a cloth)
- Aluminum, soft metals (brass)
- Glass
- Questionable items (e.g. light bulbs pipe with lead solder, electronic component parts) which could be considered mixed or hazardous waste.
- Other categories, if applicable.

7.4.4 After all decontamination operations have been completed, an RPT will perform a release survey of the decontamination area and de-post the area in accordance with CABRERA procedures OP-001 and OP-019.

8.0 REFERENCES

- Radiation Safety Program, Cabrera Services Inc., Manual
- AP-006, *Respiratory Protection Program*, Cabrera Services Inc., Operating Procedure
- AP-012, *Radiation Work Permits*, Cabrera Services Inc., Operating Procedure
- AP-013, *Packaging Radioactive Material*, Cabrera Services Inc., Operating Procedure
- AP-014, *Classifying Radioactive Waste*, Cabrera Services Inc., Operating Procedure
- OP-001, *Radiological Surveys*, Cabrera Services Inc., Operating Procedure
- OP-004, *Unconditional Release of Material from Radiological Control Areas*, 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, *Operation of Alpha-Beta Sample Counting Instrumentation*, Cabrera Services Inc., Operating Procedure
- OP-023, *Operation of Micro-R Survey Meters*, Cabrera Services Inc., Operating Procedure
- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure

9.0 REQUIRED RECORDS

The records generated by the use of this procedure are documented in accordance with the provisions of referenced CABRERA procedures. No new records are created.

10.0 ATTACHMENTS

None

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Radiological Posting

OP-019

Revision 0

Reviewed By: _____ Date: 1/24/00

David Watters, Radiological Safety Engineer

Approved By: _____ Date: 1/24/00

Steven Mascinlli CHP CSP, Radiation Safety Officer

Approved By: _____ Date: 1/24/00

Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

This procedure provides the methods Cabrera Services, Inc. (CABRERA) uses to control radioactive materials. Adherence to this procedure will provide reasonable assurance that personnel will remain free of contamination, contamination will not spread beyond the designated contamination area, and personnel exposures will be maintained As Low As Reasonably Achievable (ALARA).

2.0 APPLICABILITY

This procedure will be used by CABRERA personnel to control and contain radioactive materials. The following are types of controls methods that will be employed:

- Posting requirements for radioactive materials.
- Establishing and posting radiation areas.
- Establishing and posting contaminated areas.
- Establishing and posting airborne radioactivity areas.

3.0 PRECAUTIONS, LIMITATION, AND REQUIREMENTS

3.1 Precautions

3.1.1 If a HPT is unable to perform this procedure due to errors, extenuating circumstances, or for any reason, the HPT shall immediately stop and notify the RSO.

3.2 Limitation

None

3.3 Requirements

None

4.0 REFERENCES

- 10 CFR 20, Subpart F Surveys and Monitoring
- 10 CFR 20.2103 Records of Surveys
- RSP Radiation Safety Program
- AP-001 Record Retention
- AP-010 Personal Protective Equipment
- AP-015 Radioactive Materials Brokering

- OP-020 Operation of Contamination Survey Instrument
- OP-021 Alpha-Beta Sample Counting Instrument
- OP-022 Operation of Ionization Chambers
- OP-023 Operation of Micro-R Survey Meters

5.0 DEFINITIONS AND ABBREVIATIONS

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

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

5.3 Radiation Survey – is defined as 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.

5.4 ALARA – (acronym for “as low as is reasonably achievable”) An approach to radiation exposure control to maintain personnel radiation exposures as far below the federal limit as technical, economical and practical considerations permit.

5.5 Radioactive Materials – Materials containing or capable of emitting alpha particles, beta particles, gamma rays, X-rays, neutrons and/or other ionizing radiations.

5.6 Airborne Radioactivity Area – A room, enclosure or area in which radioactive material is dispersed in the form of dusts, fumes, mists, vapors, or gases and the concentration of the of the dispersed radioactive materials in excess of:

5.6.1 The derived air concentrations (DAC’s) specified in Table 1, Column 3 of Appendix B, Title 10 Part 20 of the Code of Federal Regulations.

5.6.2 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 percent of the annual limit on intake (ALI) or 12 DAC-hours.

6.0 EQUIPMENT

None Required

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – the PM is responsible for ensuring that personnel assigned the task of establishing and posting restricted areas are familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation safety Officer (RSO) – The RSO is responsible for monitoring compliance with this procedure and training personnel in establishing and posting restricted areas. The RSO can also assist in the interpretation of the results obtained during surveys.

7.3 Radiological Field Supervisor (RFS) – During field assignments, the RFS is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the RFS will act as the RSO's duly authorized representative for radiological issues.

7.4 Health Physics Technicians (HPT) – The HPT establishing and posting restricted areas are responsible for knowing and complying with this procedure.

8.0 INSTRUCTIONS

8.1 Posting Requirements for Radioactive Materials

8.1.1 Any area or room in which there is used or stored an amount of licensed material exceeding 10 times of the quantity of such material specified in Appendix C, Title 10 Part 20 of the Code of Federal Regulations shall be posted with a sign or signs "Caution Radioactive Materials Area" or "Danger, Radioactive Materials".

8.1.2 When posting a room as required in step one, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area containing the license material shall be bounded by a yellow and magenta/black rope or ribbon securely fastened to stanchions, posts or other durable devices and signs shall be displayed in all accessible directions.

8.1.3 Any container, which contains licensed material in quantities equal to or greater that the quantities listed in Appendix C, Title 10 Part 20 of the Code of Federal Regulation shall be posted with a sign or label bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIALS" OR "DANGER, RADIOACTIVE MATERIALS".

8.1.4 When posting a container as required by step three, the label should also state the radionuclide present in the container, the activity in the container, the date at which the activity was determined, the radiation levels emanating from the unshielded radioactive source, and the levels from the container holding the radioactive source. The label shall also state the mass enrichment if different from natural enrichment and the kind of material (encapsulated source, liquid, powder. etc.).

8.1.5 Posting of containers is not required if the containers are in transport and packages and labeled in accordance with the regulations of the Department of Transportation. (Title 49 Parts 172 and 173 of the Code of Federal Regulations). Containers, which are awaiting shipment at a facility, are subject to posting requirements as specified in 8.1.1

8.2 Establishing and Posting Radiation Areas

8.2.1 Any area accessible to personnel in which there exists ionizing radiation at dose rate levels such that an individual could receive a deep dose equivalent in excess of 5 mrem in 1 hour at 30 cm from the source of from any surface that the radiation penetrates shall be identified and posted with a sign “CAUTION RADIATION AREA”.

8.2.2 A Micro-R Meter or other calibrated dose rate meter is used to identify the boundary location of the 5 mrem/hr dose rate.

8.2.3 If an entire room or most of the room is at or above the 5 mrem/hr level, a sign should be placed on each entrance door to the room. If the area to be posted is not a room, the area at or above the 5 mrem/hr level shall be bounded by a yellow and magenta/black rope or ribbon securely fastened to stanchions, posts or other durable device and signs shall be displayed in all accessible directions.

8.2.4 An exemption to this posting requirement is allowed in areas or rooms containing radioactive materials for periods less than 8 hours, if each of the conditions is met:

8.2.4.1 The materials are constantly attended to during these periods by an individual who takes the precautions necessary to prevent the exposure to radiation or radioactive materials in excess of the limits specified in the RSP; and

8.2.4.2 The area or room subject to the licensee’s control. For example, the area around the truck loading radioactive waste does not require posting if the above conditions are met.

8.2.5 If the dose rates above 100 mrem/hr are encountered, control access to the area and contact the RSO or duly authorized representative for posting instructions.

8.3 Establishing and Posting Contaminated Areas

8.3.1 A restricted area that has fixed and removable radioactive materials in the form of dusts, particulates or sorbed contaminants which are above the limits specified in the RSP shall be identified and posted with a “CONTAMINATED AREA” sign.

8.3.2 Contamination levels are determined using procedure OP-001 (Radiological Surveys) and the results of the survey measurements compared to the contamination limits specified in the RSP.

8.3.3 If an entire room or most of the room is above the contamination criteria, a sign should be placed on the entrance door to the room. If the area to be posted is not a room, the above area contamination criteria shall be bounded by a yellow and magenta/black rope or ribbon securely fastened to stanchions, posts or other durable device and signs displayed in all accessible directions.

8.3.3.1 A single entry point shall be established to access the contaminated area. A step-off pad is placed at the entry point, which provides a defined boundary between contaminated and restricted areas.

8.3.3.2 Receptacles for protective clothing and waste materials shall be placed just inside the entry point to collect protective clothing from personnel exiting the area.

8.3.3.3 If work activities in the work areas are likely to generate significant dusts containing radioactive materials, the area should be enclosed within a containment to prevent the spread of contamination beyond the identified contaminated area.

8.4 Establishing and Posting Airborne Radioactivity Areas

8.4.1 CABRERA’s policy is to minimize (and protect, if practical) the amount of radioactive materials taken into a workers body. In order to accomplish this, Airborne Radioactivity Areas are posted at 10% DAC, as specified in Table 1, Column 3 of Appendix B of 10 CFR 20. Maintaining the airborne activity below these limits will eliminate any posting requirements.

8.4.2 To verify that these limits are not exceeded, an air sample is taken during each work activity, which could create an airborne radioactivity hazard. The results of these samples are compared with the above limits to verify the limits are not exceeded. If these limits are exceeded, immediately contact the RSO or duly authorized representative.

8.4.3 A room, enclosure or area shall be posted with a “CAUTION, AIRBORNE RADIOACTIVITY AREA” or “DANGER, AIRBORNE RADIOACTIVITY AREA” if radioactive material is dispersed in the form of fumes, dusts, mists, vapors, or gases and the contamination of the dispersed radioactive materials is in excess of:

8.4.3.1 The derived air concentration (DAC) specified n Table 1, Column 3 of Appendix B, Title 10 Part 20 of the Code of Federal Regulations.

8.4.3.2 Concentration 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 percent of the annual limit on intake (ALI) or 12 DAC-hours.

8.4.4 If a room, enclosure or area requires posting as specified in 8.4.3, immediately stop work activities and contact the RSO or duly authorized representative for instructions.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

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

9.2 Records

9.2.1 Record any radioactive materials posting made in the project logbook. Include the date, location, and all information posted.

9.2.2 Record the date and the location of any radiation areas established in the project logbook. Include a sketch of the area and radiation area boundary on survey forms.

9.2.3 Record the date and location of any contaminated areas established in the project logbook. Include a sketch of the area and contaminated area boundary on survey forms.

9.2.4 Record the date and location of any airborne radioactivity areas established in the project logbook. Include a sketch of the area on survey forms. Indicate time and date of any notifications required by this procedure.

9.2.5 Radiological survey records, routine survey schedules, and tracking forms are generated during the performance of this procedure.

9.2.6 Documented information shall be legibly written in ink.

9.2.7 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.

9.2.8 The HPT performing the posting shall ensure that this procedure is the most current and approved revision.

9.2.9 The HPT performing the posting shall review Forms and any other applicable forms for accuracy and completeness.

9.2.10 Entries on Forms and any other pertinent forms must be dated and initialed by the HPT performing the posting to be valid.

9.2.11 The RSO or duly authorized representative shall review any applicable completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

None

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

ALPHA-BETA COUNTING INSTRUMENTATION

OP-021

REVISION 1.0

Reviewed by:

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

Approved by:

Henry Siegrist

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

1.0 PURPOSE

This procedure provides instruction on the operation and setup of an alpha/beta sample counter. Adherence to this procedure will provide a reasonable assurance that the surveys performed have reproducible results.

2.0 APPLICABILITY

This procedure will be used by Cabrera Services Inc., (CABRERA) personnel operating an alpha/beta sample counter during surveys. Types of surveys that may use an alpha/beta sample counter are:

- Smear surveys performed to determine the removal of alpha and beta contamination on facility surfaces, equipment, waste, source packages, etc.
- Air sample surveys performed in a worker's breathing zone, a work area, or around the perimeter of a work site to determine alpha and beta air concentrations.

3.0 DEFINITIONS

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

3.2 Smear Sample Survey – A technique using a two-inch diameter filter paper to determine removable contamination of alpha and/or beta emitting radioactive material over a 100 cm^2 area.

3.3 Air Sample Survey – A technique where particulates are collected, from a known volume of air drawn through a filter paper, and the concentrations of airborne alpha and beta activity, associated with the particulates, are determined by sample counting.

3.4 Chi-Square Test – A statistical test used to evaluate the operation of a sample counter by determining how data fit a series of counts to a Poisson distribution.

3.5 Daily Calibration Check – A determination of alpha and beta sample counting efficiency by counting radioactive standards that are traceable to the National Institutes of Science and Technology.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

If any instrument inconsistencies are observed (e.g., unusually high or low background counts, source checks outside the tolerance range), remove the instrument from use and report the condition to the Site Radiation Safety Lead (SRSL) or other duly authorized representative.

4.2 Limitations

This instrumentation should be set up for use in a low background area, as determined by the SRSL or other duly authorized representative.

4.3 Requirements

4.3.1 Calibration sources will be traceable to the National Institutes of Science and Technology (NIST).

4.3.2 Survey instrument calibrations will be performed by a calibration facility licensed by the Nuclear Regulatory Commission or Agreement State.

4.3.3 A battery or power source check, general observation of instrument condition, background check, and source check will be performed each day before instrument use. A second daily quality check that includes all of the above can be performed at the end of daily work activities, if determined to be necessary on a project site.

4.3.4 The alpha/beta sample counter will be checked for proper calibration daily with a NIST-traceable source, when in use.

4.3.5 Chi-Square tests will be verified and noted as currently valid, when performed.

4.3.6 The Radiation Protection Technician (RPT) will ensure that the attachment forms are the most current and approved revisions.

4.3.7 The RPT will review completed forms for accuracy and completeness; all entries must be dated and initialed, by the RPT, to be valid.

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

5.0 EQUIPMENT

Ludlum Model 2929 sample counter, or equivalent, coupled to a Ludlum Model 43-10-1 alpha/beta scintillation detector with sample tray. Equivalent instruments, based on project need, can be utilized (i.e. Ludlum Model 3030, Canberra Tennelec).

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) – Ensuring that personnel assigned the task of operating alpha/beta sample counters know and understand this procedure, are adequately trained in its use, and have easy access to a copy.

6.2 Radiation Safety Officer (RSO) – Verifying that personnel comply with this procedure and are trained in the use of alpha/beta sample counters described in this procedure.

6.3 Site Radiation Safety Lead (SRSL) – During field assignments, the SRSL is responsible for ensuring that this procedure is properly 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 Technician (RPT) – The RPTs, using alpha/beta sample counters, are responsible for knowing and complying with this procedure.

6.5 CABRERA personnel – Individuals performing work with an alpha/beta counter will know and understand the requirements set forth in the current and approved version of this procedure.

7.0 PROCEDURE

7.1 Instrument Inspection

7.1.1 Before each use, perform the following checks:

- Verify that the instrument has a current calibration label.
- Visually inspect the instrument for physical damage and defects.
- Verify that the high voltage and high voltage potentiometer settings agree with the calibration sheet.

7.1.2 Remove and tag the instrument "OUT OF SERVICE" if it fails any of the above criteria and notify the SRSL or the duly authorized representative.

Note: Any defects, damages or other physical abnormalities require that the instrument be removed from service and the SRSL, or other duly authorized representative, be notified.

7.2 Chi-Square Test

Note: The Chi-Square Test is not always required, but is a good verification check on the instrument operability and count setup routines, at the beginning of a project. A Chi-Square Test is only required whenever significant changes have been made to the equipment, such as a detector tube (Model 43-10-1) change out and subsequent recalibration or decontamination of the equipment. Contact the SRSL for guidance.

7.2.1 Set up the instrument in a low background area.

7.2.2 Ensure the high voltage potentiometer is positioned according to the posted instrument label. Adjust if necessary.

7.2.3 Set the time multiplier switch to "x1".

7.2.4 Set the instrument-preset timer to one (1) minute.

7.2.5 Insert the alpha calibration standard into center of the sample tray, slide

the sample tray under the detector and depress the “COUNT” button to obtain a one minute count.

7.2.6 Upon completion of the count, record digital counts appearing in the alpha display in the “Xi” column on the Chi-Square Data Sheet (Attachment A).

Note: 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 Repeat counting sequence, ensuring that the count source is removed and repositioned within the count holder, thus ensuring count position variability consistent with actual use counting. No instrument settings can be changed during this count sequence. Continue until a total of 20 counts have been taken and recorded in the “Xi” column on the Chi-Square Data Sheet (Attachment A).

7.2.8 Add the 20 counts recorded in the “Xi” column and record in the “Sum” column. Then divide by 20 to obtain the mean number of counts (Xm) and record on the line “Xm. “

7.2.9 Calculate the individual count “Xi” difference from the mean (Xm) value and record in the “(Xi-Xm)” column the Chi-Square Data Sheet for all 20 values.

7.2.10 Calculate (Xi-Xm)2, sum the “(Xi-Xm)2 ” column, and record on the Chi-Square Data Sheet.

7.2.11 Calculate the value of Chi- Square using the following formula:

$$X^2 = \frac{\sum (X_i - X_m)^2}{X_m}$$

7.2.12 The value of Chi-Square should be between 8.91 and 32.8 (represents a probability between 0.025 and 0.975). Record this value at “X2.“ If the Chi-Square value falls outside this range, contact the SRSL or other duly authorized representative for further instructions.

7.2.13 Sign and date the Daily Calibration Check form (Attachment B) and forward the results to the SRSL or other duly authorized representative for review. Keep an electronic copy in the project files.

7.3 Initial Quality Control Check

7.3.1 Ensure the high voltage potentiometer is positioned according to the posted instrument label. Adjust slowly, if necessary.

7.3.2 Set time multiplier switch to “x1.”

7.3.3 Set the instrument-preset timer to the pre-determined background count

time set by the SRSL. Counter MDAs need to be setup for 50% of the release limit for the given isotope.

7.3.4 Record the source type to be used and corresponding serial number on the proper line indicated on the Daily Calibration Check form. Use separate rows of the form for each source efficiency to be calculated.

Note: Approved electronic templates may be used in place of this form as long as the equivalent information is provided, as described in this procedure.

7.3.5 Insert a blank sample into the center of the sample tray, slide the sample tray under the detector and depress the "COUNT" button to obtain a background count.

7.3.6 Record the background count rate in the cell labeled "Bkg Count Time" on the Daily Calibration Check form.

7.3.7 Repeat the counting sequence until a total of 10 counts have been taken and recorded in the "Bkgd" row on the Daily Calibration Check form. Calculate the average of the 10 counts and the standard deviation (σ) for the average count.

7.3.8 Reset the instrument-preset timer to the pre-determined source count time set by the SRSL.

7.3.9 Remove the blank sample and insert the alpha or beta calibration standard into the center of the sample tray, slide the sample tray under the detector and depress the "COUNT" button to obtain a source count.

Note: Be sure to turn the source approximately 90 degrees with every count as this will give a wider range since not all sources are uniform in nature.

7.3.10 Record the source count rate in the columns labeled "Source #1 Count Time" and "Source #2 Count Time," respectively, on the Daily Calibration Check form

7.3.11 Repeat the counting sequence until a total of 10 counts have been taken and recorded for both alpha and beta check sources in the "Source #1" and "Source #2" rows on the Daily Calibration Check form. Calculate the average of the 10 counts for each source and (σ) for the average counts.

7.3.12 Remove calibration standards and place in source holders.

7.3.13 Initial and date the Daily Calibration Check form and forward the results to the SRSL, or other duly authorized representative, for review.

7.3.14 Record all data electronically in an alpha/beta counting spreadsheet and keep in project files. All records, including electronic records, must be managed in accordance with OP-187.

7.4 Daily Calibration Check

7.4.1 Ensure the high voltage potentiometer is positioned according to the posted instrument label. Adjust slowly, if necessary.

7.4.2 Set time multiplier switch to “x1”.

7.4.3 Set the instrument-preset timer to the pre-determined background count time, set by the SRSL.

7.4.4 Record the source type to be used and corresponding serial number on the proper line indicated on the Daily Calibration Check form. Use separate rows of the form, for each source efficiency, to be calculated.

7.4.5 Insert a blank sample into the center of the sample tray, slide the sample tray under the detector and depress the “COUNT” button to obtain a background count.

7.4.6 Calculate and record the background total counts and count rate in the columns labeled “Bkgd” and “Bkg Count Time” respectively on the Daily Calibration Check form. The background count rate in CPM (counts per minute) can be calculated as follows:

$$CPM = \frac{Total\ Counts}{Total\ Time}$$

7.4.7 Remove the blank sample and insert the alpha or beta calibration standard into the center of the sample tray, slide the sample tray under the detector and depress the “COUNT” button to obtain a source count.

7.4.8 Upon completion of the measurement, calculate and record the total counts and count rate in the columns labeled “Total Counts” and “CPM” respectively, under ‘Source’ information on the Daily Calibration Check form. The count rate (CPM) can be calculated as listed in Step 7.4.6.

7.4.9 Calculate Net Source CPM, as below, and record on the Daily Calibration Check form under “Net CPM.”

$$Net\ Source\ CPM = CPM - BKG\ CPM$$

Note: Obtain activity (DPM) value from the source certification paperwork. Decay correct activity, if needed.

7.4.10 Use the source disintegration per minute (DPM) to calculate the 4 pi efficiency, as shown below, and check against calibrated efficiency. This data can be recorded in the electronic template.

$$\%\ Efficiency = \frac{Net\ Source\ CPM}{DPM} * 100$$

7.4.11 To calculate the efficiency, for the next source, remove the current source standard and insert a new source standard, then repeat steps 7.4.1 through 7.4.10, as necessary.

7.4.12 Remove calibration standards and place in source holders.

7.4.13 Generate an excel control chart tracking the daily efficiencies and notify the SRSL or duly authorized representative if any point falls outside of 2σ variance.

Note: For the first day on the control chart, use five data points to begin the trend line.

8.0 REFERENCES

- Radiation Safety Program, Cabrera Services Inc., Manual
- AP-005, *ALARA*, Cabrera Services Inc., Operating Procedure
- OP-001, *Radiological Surveys*, Cabrera Services Inc., Operating Procedure
- OP-187, *Records Management*, Cabrera Services Inc., Operating Procedure
- U.S. Nuclear Regulatory Commission, Consolidated Guidance About Material Licenses, *Vol.11 - Program-Specific Guidance About Licenses of Broad Scope*, NUREG-1556, (1999).

9.0 REQUIRED RECORDS

The following records must be maintained whether paper or electronic:

- Chi-Square Data Sheet (when applicable)
- Daily Calibration Check
- Excel calibration records

10.0 ATTACHMENTS

Attachment A – Chi-Square Data Sheet

Attachment B – Daily Calibration Check

Attachment A

Chi-Square Data Sheet

Chi-Square Data Sheet

Date:_____Instrument:_____Serial Number:_____ X^2_____

Alpha Source No./Activity:_____Beta Source No./Activity:_____

Count Number	X_i	(X_i-X_m)	$(X_i-X_m)^2$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
Sum		\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	
X_m		\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\

Prepared By: _____ Date: _____
Print/Sign

Reviewed By: _____ Date: _____
Print/Sign

Attachment B

Daily Calibration Check

Daily Calibration Check

Make	Model	S/N	Probe	S/N	Cal Date
Bkg Count Time	**Source #1 Count Time**	**Source #2 Count Time**	**Source #1 ID**	**Source #2 ID**	**Cal Due Date**

Date(s)										
Intial QC's	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Init.**
Bkgd											
Source #1											
Source #2											

Daily QC's

Date	Bkgd	Source #1 ( ) α/β/γ	Source #2 ( ) α/β/γ	Battery OK?	Comments	Init.
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		
				Yes / No		

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Operation of Micro-R Meters

OP-023

Revision 0

Reviewed By: _____ Date: 1/24/00

David Watters, Radiological Safety Engineer

Approved By: _____ Date: 1/24/00

Steven Masciulli CHP, CSP, Radiation Safety Officer

Approved By: _____ Date: 1/24/00

Henry Siegrist CHP, P.E., Corporate Health Physicist

1.0 PURPOSE

The purpose of this procedure is to provide instruction for the operation of the micro-R meter for gamma radiation surveys. Adherence to this procedure will provide reasonable assurance that the radiological surveys performed have reproducible results.

2.0 APPLICABILITY

This procedure will be used by Cabrera Services, Inc. (CABRERA) personnel operating the micro-R meter during gamma radiation surveys. The micro-R meter is used to determine gamma radiation levels from facility surfaces, equipment, waste and source packages, etc., containing gamma emitting radioactive materials.

3.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

3.1 Precautions

3.1.1 Individuals performing work with the micro-R meter shall be familiar with the requirements set forth in the current and approved version of this procedure.

3.1.2 If any instrument inconsistencies are observed (e.g., unusually high or low background readings, source checks outside the acceptable range, etc.), remove the instrument from use, label it "OUT OF SERVICE" and report the condition to the Radiation Safety Officer (RSO) or duly authorized representative.

3.2 Limitations

None

3.3 Requirements

3.3.1 Calibration sources shall be traceable to the National Institutes of Science and Technology (NIST).

3.3.2 A battery check, general observation of instrument condition and source check shall be performed each day before instrument use and daily following work activities as a final verification.

3.3.3 Survey instrument calibrations shall be performed by an NRC or Agreement State licensed calibration facility.

4.0 REFERENCES

- RSP Radiation Safety Program
- ALARA ALARA Program
- AP-001 Record Retention
- OP-001 Radiological Surveys
- OP-009 Use and Control of Radioactive Check Sources
- OP-020 Operation of Contamination Survey Meters
- NUREG-1556 Consolidated Guidance About Material Licenses (Vol.11)

5.0 DEFINITIONS AND ABBREVIATIONS

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

5.2 Gamma Radiation Survey – A survey technique to determine gamma radiation levels from radioactive material(s) in facilities, materials, landmasses, etc.

5.3 Acceptance Range – A range of values that describe an acceptable daily instrument source check result.

6.0 EQUIPMENT

Ludlum Model 19 or equivalent

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – the PM is responsible for ensuring that personnel assigned the task of operating a micro-R meter is familiar with this procedure, adequately trained in the use of this procedure, and have access to a copy of this procedure.

7.2 Radiation safety Officer (RSO) – The RSO is responsible for verifying that personnel comply with this procedure and are trained in the operation of a micro-R meter described in this procedure.

7.3 Radiological Field Supervisor (RFS) – During field assignments, the RFS is responsible for ensuring that this procedure is implemented. When the RSO is not on site, the RFS will act as the RSO's duly authorized representative for radiological issues.

7.4 Health Physics Technicians (HPT) – The HPT operating the micro-R meter are responsible for knowing and complying with this procedure.

8.0 OPERATION

8.1 Instrument Inspection

8.1.1 Before each use, perform the following checks:

8.1.1.1 Verify the instrument has a current calibration label.

8.1.1.2 Visually inspect the instrument for physical damage or defects.

8.1.1.3 Position the meter switch to "BAT". Check to see that the needle falls within the "Bat Test" checkband.

- If the needle falls below the "Bat Test" checkband, install new battery(s).
- If the needle still falls outside the "Bat Test" checkband after the installation of new battery(s), tag the instrument "Out of Service" and notify the RSO or duly authorized representative.

8.1.2 Remove and tag the instrument "Out of Service" if it fails any of the criteria in Step 8.1.1.1 through 8.1.1.3 and notify the RSO or duly authorized representative.

NOTE: Any defects, damages or other physical abnormalities require that the instrument be removed from service and the RSO or duly authorized representative be notified.

8.2 Pre-operation of instrument

8.2.1 Position the meter fast/slow ("F/S") switch to "S".

8.2.2 Position the meter switch to the appropriate range scale.

8.2.3 If a Quality Control (Q.C.) acceptance range has not already been calculated, then follow the instructions below, other wise proceed to step 8.2.5.

8.2.3.1 Ensure the source and detector are in documented reproducible positions, which will be used each time this check is performed. Document this position on appropriate form.

8.2.4 Place the QC check source and detector in the documented position on appropriate form.

8.2.5 Allow the instrument reading to stabilize (approximately 30 seconds). Compare the reading to the response check criteria. If the response reading falls outside of the acceptance range, tag the instrument "Out of Service," and notify the RSO or duly authorized representative.

8.3 Operation of the instrument

8.3.1 Grid Surveys

8.3.1.1 Turn the audio switch to the “On” position.

8.3.1.2 Verify the instrument selector switch is on the lowest scale (usually the μR position). Turn the instrument selector switch to the next higher scale only if meter indication is off scale.

8.3.1.3 For a stationary grid reading in a facility or land mass, position the instrument one meter above the surface to be surveyed and allow meter to stabilize. With the instrument toggle switch set in the "SLOW" position, the meter reaches 90% of its final reading in 22 seconds. Record the average meter indication in μR/hr on appropriate form(s).

Note: Two survey methods (step 8.3.1.4 or 8.3.1.5) can be used to obtain contact readings in the survey grids. The survey method used will be specified in the site specific work plan.

8.3.1.4 For a scan survey, make sure the meter response is set to fast and suspend the instrument from a strap which locates the detector at surface or ground level. Move the instrument slowly over the surface while walking in an "S" pattern unless otherwise instructed by the RSO or duly authorized representative. Areas, which could concentrate radioactive materials such as drainage ditches, floor cracks, and wall/floor joints, should be surveyed. Observe meter indication and listen for increases in audible clicks from the speaker. If elevated readings above background are observed, a stationary survey shall be performed (at one-meter height and at the surface) at the point of elevated activity. Record area meter indications above background in μR/hr on appropriate form.

8.3.1.5 As an alternate to the "S" pattern survey used in step 8.3.1.4, the survey grid can be divided into subgrids and readings taken as directed by the site work plan. Elevated measurements should be performed in the same manner as above (i.e., at one meter and at the surface). The readings from each measurement are recorded on appropriate form.

8.3.2 Waste Container Surveys

8.3.2.1 Set the instrument scale to accommodate the highest expected radiation level. If radiation levels may approach 5000 μR/hr (5 mR/hr) obtain an instrument with appropriate range before performing any radiation surveillance.

8.3.2.2 Slowly scan the total surface of the package and record the maximum contact reading obtained on appropriate forms.

8.3.2.3 Obtain instrument readings at one meter from all sides of the package and record the maximum reading obtained on appropriate form.

8.3.3 Final Verification

Upon completion of work activities, repeat steps 8.1.1.1 through 8.2.2 and 8.2.4 through 8.2.5, as a final verification that the instrument is working properly

8.3.4 Additional Information

8.3.4.1 In a uniform background radiation field (without interfering sources of radiation), methods such as selectively shielding the detector, soil sample analysis, etc., can be used to differentiate between extraneous radioactive sources (e.g., skyshine or radioactive waste shipment containers), naturally occurring radioactive material and/or radioactive contamination.

8.3.4.2 Note the location of installed devices, which contain radioactive material and could cause elevated background radiation levels in localized areas.

8.3.4.3 Land mass surveys might contain areas with naturally occurring radioactive materials, which will elevate background radiation levels.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 The health physics technician performing the survey shall ensure that this procedure is current.

9.2 Records

9.2.1 Documented information shall be legibly written in ink.

9.2.2 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.

9.2.3 The health physics technician performing the survey shall review appropriate forms and any other applicable forms for accuracy and completeness.

9.2.4 Entries must be dated and initialed by the health physics technician performing the survey to be valid.

9.2.5 The RSO or duly authorized representative shall review any applicable completed forms. The review shall be for accuracy and completeness.

10.0 ATTACHMENTS

None

CABRERA SERVICES
RADIOLOGICAL • ENGINEERING • REMEDIATION

OPERATING PROCEDURE

FOR

SAMPLE MANAGEMENT & SHIPPING

OP-362

REVISION 2.0

Prepared by:

_____ April 13, 2015

Carl Young, PG — Date
Project Manager

Approved by:

_____ April 13, 2015

Sean Liddy, CSP — Date
Quality Assurance Manager

1.0 PURPOSE

The purpose of this Operating Procedure (OP) is to provide Cabrera Services Inc. (Cabrera) personnel the methods to utilize when managing and shipping field samples. Adherence to this procedure will provide the following:

- Consistency in sampling labeling/numbering.
- Assurance that the results are traceable to a specific sample location, type and matrix.
- Track disposition of samples and associate quality control samples with primary samples.
- Assure the safe handling of samples during the shipping process through proper packaging
- Assurance that the analyses performed have reproducible results.

2.0 APPLICABILITY

This procedure applies to all Cabrera Services Inc (Cabrera) employees and operations. Personnel shall utilize this procedure for all environmental field samples unless specified otherwise through the project specific Field Sampling Plan (FSP), or Quality Assurance Project Plan (QAPP). Personnel must assure that the specifications of this SOP agree with the specifications listed in the Project Work Plans.

3.0 DEFINITIONS

3.1 Project Plans - For the purposes of this procedure, a generic term describing the project implementing plans that contain the information associated with the requirements for mandated sampling. These include, but are not necessarily limited to:

3.2 Project Work Plan (PWP) - The over-arching project plan used to manage both project execution and project controls. A primary use is to document planning assumptions and decisions including quality assurance and quality control (QA/QC) measures regarding data gathering and deliverables.

3.3 Field Sampling Plan (FSP) - Provides specific directions for conducting each separate field sampling activity and presents the rationale and design, for the work, as well as the field procedures for each specific activity required. Field operations and documentation are also described and may include discussions on field logbooks, photographic records, sample documentation, field analytical records, and procedures for their management and retention.

3.4 Quality Assurance Project Plan (QAPP) - Focuses primarily on the analytical methods and QA/QC procedures that are used to analyze and manage environmental samples and their resulting data. The QAPP also presents the

project organization, objectives, procedures, functional activities, and specific QA/QC activities associated with sampling, data management and record retention.

3.5 Site Safety and Health Plan (SSHP) – Provides evacuation routes for the site and immediate area; site-specific safety information; MSDS for any relevant chemicals of concern; and names and telephone numbers of common emergency contact personnel for the worksite. In addition, the SSHP may also contain sampling activities required to monitor worksite safety and health.

3.6 Quality Assurance (QA) - All procedures, practices, records, and other documentation required to provide confirmation that project activities are completed in a manner compliant with regulations, specifications, and/or contract requirements.

3.7 Quality Control (QC) - For the purposes of this procedure, actions taken to control the variable attributes of the sampling and analytical processes to meet the data quality objectives described in the project plans.

3.8 Sample Tracking Log - A quality control form that lists all of the samples collected, list the analyses to be performed, and tracks their destination.

3.9 Chain of Custody - The Chain of Custody lists and describes a shipment of samples that leave the custody of the sampler and are transferred to the custody of the laboratory. For additional information, please refer to OP-008, Chain of Custody.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

Many environmental field samples are preserved using concentrated acids. These preservatives are typically placed in otherwise empty containers by the laboratory. Personnel must wear appropriate PPE and exercise appropriate care when handling sample containers. Preservative may leak from containers during shipment, or may be released into packaging from broken containers. Preservative can be splashed into the air when containers are opened.

When environmental samples are preserved (i.e., acidification or alkalinization), this is accomplished by adding a regulated hazardous material to the sample. Despite the addition of these preservatives, the samples will not be considered regulated hazardous materials, as long as the following concentrations are complied with:

Preservative		Desired in Final Sample		Quantity of Preservative (mL) for specified container				
		pH	Conc.	40 mL	250 mL	500 mL	1 Liter	1 Gallon
HCl	3N	<2	0.04%	0.15	1	2	3	10
HNO_3	4.5N	<2	0.15%	-	3	6	12	Not Authorized
H_2SO_4	18N	<2	0.35%	-	1	2	4	16
NaOH	30%	>12	0.08%	-	0.5	1	2	8

Derived from requirement of 49 CFR Part 172 and 40 CFR Part 136.3.

Samples taken for analyses that are anticipated to be relatively low in concentration (i.e., in the low ppm range for total contaminants) are generally not subject to the requirements of the DOT regulations, however; if the samples contain any free-phase layer or exhibit characteristics found in Hazard Class 1 through 9, the sample must be shipped as a regulated hazardous material (please refer to OP-391, HAZMAT/DG Shipping and contact Cabrera's HAZMAT Shipping Expert for additional Guidance). DOT / IATA Shipper Training is required in order to package and ship hazardous materials.

Even though environmental samples, as defined by this procedure, are not regulated by the US Department of Transportation (DOT), they must be packaged and shipped in accordance with good product stewardship practices. Samples must be packaged properly to avoid breakage, including the use "secondary containment" in the form of plastic zipper storage bags on sample sets, and the use of a plastic "trash" bag as a liner within the cooler. US DOT and common carriers may levy severe penalties if fluids of any kind are found to be leaking from coolers.

All samples should be stored/maintained in a location with adequate ventilation. Samples having significant VOC or SVOC concentrations can slowly release vapors into a confined space over time such that local concentrations may exceed action limits.

4.2 Limitations

Onsite storage may not be appropriate for samples having short holding times. The Field Site Manager (FSM) must take into account the time required for sample shipment, receiving, and sample extraction/preparation in order to determine appropriate onsite holding times.

The Cabrera field representative who delivers (or arranges delivery of) the samples to the laboratory is responsible for ensuring that sufficient cooling material (e.g. ice) is present in the shipment container so that the sample temperature is maintained during transportation to the laboratory. This is especially critical if the samples are being transported via overnight common courier (such as FedEx) during the middle

of the summer. Always err on the side of caution by placing as much ice as possible in the shipment container; re-sampling will always be more expensive than an extra bag of ice.

4.3 Requirements

4.3.1 Sample names are unique identifiers. Sample codes must be assigned such that they discriminate a sample from any other samples.

4.3.2 Sample numbers must be recorded in at least four places:

1) On the sample container
2) On the Chain-of-Custody
3) On a Sample Control Log
4) In the field notebook.

4.3.3 Personnel using this procedure shall be familiar with the Project Work Plans.

4.4 Field Personnel shall discuss deviations to the Project Work Plans with the Project Manager. Any deviations, plus conversations with the PM, shall be documented in the project field notebook.

5.0 EQUIPMENT

- Either pre-printed or on-site printed sample labels
- Bubble wrap
- Ice
- Gallon-size water-tight freezer bags
- Trash bags
- Coolers
- Packing tape
- Custody seals
- Shipping labels
- Sample tracking log
- Field notebook
- Secured staging area with appropriate ambient temperatures and access controls

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) - The PM is responsible for implementing and ensuring compliance with the contents of the project plans, and hence the design of the sample numbering system. They also must ensure that project personnel have been trained and are qualified to implement this procedure.

6.2 Field Site Manager (FSM) - The FSM is responsible for: the execution of field activities in discussion with the PM; correctly applying the sample numbering system; and, entering information into the field notebooks.

6.3 Project Personnel - All Cabrera personnel are responsible for reading, understanding, and complying with the provisions of this procedure prior to engaging in sampling activities. In addition, site workers should discuss any deviations from the prescribed sampling protocols with the PM or FSM, and document that conversation in the project field notebook.

7.0 PROCEDURE

Environmental samples usually consist of environmental media (soil, water, air) that may have been impacted by source area materials, but not to an extent that they would contain any free product or hazardous concentrations of contaminants. Examples of these types of samples might include soils with no visible staining or strong odors, surface and groundwater samples with no floating product, and air samples collected on sorbent tubes or filters.

The following subsections outline the requirements for the proper labeling, numbering, tracking, storage, packaging, and shipping of environmental samples on Cabrera project sites. All samples are to be handled by as few people as possible and the chain of custody form must document the change of possession by the appropriate dated signatures.

7.1 Sample Labeling

Sample labels provide specific information that is permanently affixed to the sample container using a water-proof label and are necessary to prevent misidentification of samples. Preprinted sample labels are to be used unless alternative labels are approved by the PM. Where necessary, the label will be protected from water and solvents with a clear covering of transparent tape. Use an ink pen or water-proof marker when writing on labels. Each label will contain the following information:

- Name or initials of the collector
- Date and time of collection
- Job name and number
- Sample number and/or boring number and depth
- Preservative (if required).

7.2 Sample Numbering

The sample numbering process consists of the assignment of a unique sample identification number to be placed on sample labels or tags, and chain-of-custody form. Primary samples and QC samples will each be assigned unique sample identification (ID) numbers as outlined below, unless an alternate numbering process is specified in a site-specific FSP or QAPP. The sample ID will be composed of six components separated by dashes, as shown below:

[_ _] - [_ _] - [_ _] - [_ _] - [_ _] - [_ _]

1 2 3 4 5 6

7.2.1 Component 1 - Defines the location or area of interest, as designated in the PWP. This component must be a small combination of letters and/or numbers (i.e., alphanumeric) without special characters. For example:

- If the site is divided into two “areas of concern,” you might use AOC1 and AOC2 as the location descriptors; or
- If the site contains 12 “survey units,” you might use SU01 – SU12 as the location descriptors. (Consider using the symbol ”Ø” instead of “0” in this context to avoid misidentification by the laboratory.)

Note: At a site with a single sampling area, this numbering component should be eliminated unless another unique discriminator is required. Do not use a site abbreviation as this is common to all samples collected.

7.2.2 Component 2 – Defines the station type:

BF	=	Backfill
CPT	=	Cone Penetrometer
D	=	Drum
EXB	=	Excavation – bottom sample
EXE	=	Excavation – east sidewall sample
EXN	=	Excavation – north sidewall sample
EXS	=	Excavation – south sidewall sample
EXW	=	Excavation – west sidewall sample
MW	=	Monitor Well
P	=	Pipe
SB	=	Soil Boring (includes groundwater acquired from borings)
SP	=	Stockpile
T	=	Tank

7.2.3 Component 3 - Identifies the station number in the area of interest. Number sequences start from 001 in each area [component 1].

7.2.4 Component 4 – Defines the sample matrix using letters:

A	=	Air or soil gas
E	=	Effluent (waste water)
S	=	Soil sample in general or Subsurface Soil Sample
SS	=	Surface Soil Sample
SD	=	Sediment Sample
GF	=	Groundwater Sample – Filtered
GU	=	Groundwater Sample – Unfiltered
W	=	water sample in general or Surface Water Sample

7.2.5 Component 5 – Defines either the primary or QC sample collected:

P	=	Primary Sample
MS	=	Matrix Spike
MSD	=	Matrix Spike Duplicate
DUP	=	Duplicate
EB	=	Equipment (Rinsate) Blank
TB	=	Trip Blank
FB	=	Field Blank
QA	=	QA Split

7.2.6 Component 6 – Identifies the depth at which the sample was taken:

- For soil and sediment samples, it will designate the top of the sample interval, in feet.
- For groundwater samples, it will designate the depth below ground surface for the entry point of the sampling device (for example, the depth of tubing placement for a peristaltic pump).
- For surface water samples, it will designate the depth below water surface from which the sample was collected.

To maintain a unique sample ID, the sample database should be reviewed to identify the last sample number used for each station.

Sample Naming Convention Examples:

- The 16th primary soil sample collected at Building 23 from a soil boring and collected from a depth of 8 feet would be named 23-SB-16-S-P-08.
- The field duplicate, for the sample above, would be named 23-SB-16-S-DUP-08.
- The equipment blank, for the sample above, would be named 23-SB-16-W-EB-08.

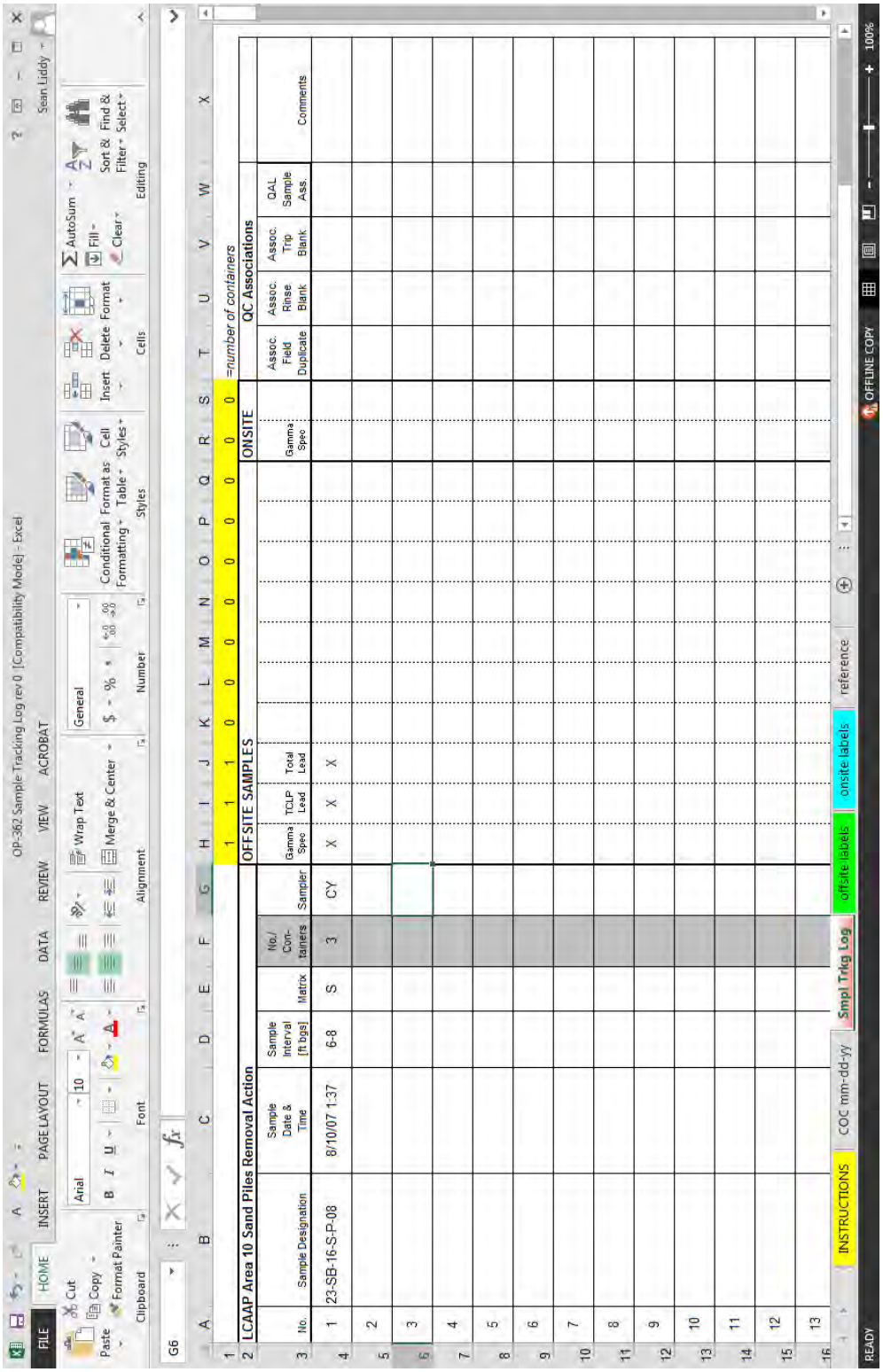
7.3 Sample Tracking

The tracking of samples shall be completed by making accurate record of the samples collected in a field log book, a sample tracking log, and through the use of a Chain of Custody. The QAPP should specify whether the lab's Chain of Custody should be used or whether a Cabrera chain of custody should be used. Information on how to complete a Chain of Custody may be found in Cabrera OP-008, Chain of Custody.

Sample tracking provides assurance that appropriate analyses are requested, and that the sample can be entered into the site data set. Cabrera's Sample Tracking Log is an electronic tool (Excel File) used to capture information about the sample, including associated Quality Control samples, and includes options for generating sample labels and printing chain of custodies.

The electronic Sampling Tracking Log is especially useful for large sampling projects. A Work Instruction on its use is been included as Attachment A.

An example of the Sample Track Log from the Excel workbook is below:



Example of Sample Tracking Log in Excel Workbook.

7.4 On-site Sample Storage

The typical uses for onsite sample storage include: holding samples when they cannot be shipped, holding sample splits pending decisions on additional analysis, holding samples following onsite analysis pending decisions on final sample disposition.

Samples must be maintained in the custody of the FSM or his designee. In order to maintain a chain-of-custody, the sample storage area must not be accessible by unauthorized personnel, either through the use of custody seals or locks.

The sample storage area must have the proper environmental controls to keep the samples within an acceptable temperature range.

The FSM shall use the Sample Tracking Log, or similar means, to monitor the location of each of the samples.

7.5 Sample Packaging

The procedures to be employed by the Cabrera field representative for sample packaging will vary based on the types of samples, containers, and method of shipment to the laboratory. Cabrera's procedures for sample packaging are as follows unless site-specific planning documents (such as a QAPP) require alternate procedures:

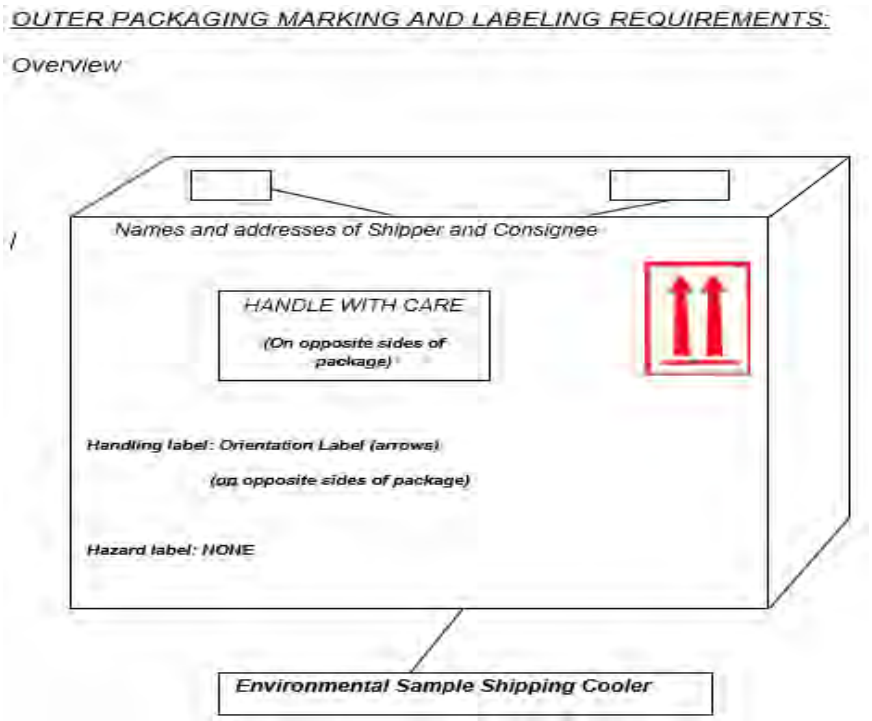
- For 40 ml volatile organic analysis (VOA) sample bottles, the Cabrera field representative should either have a foam block for the samples or sufficient plastic bags and shipping material (such as bubble wrap). The foam block is preferable for protecting the VOA bottles from breaking. Otherwise, the Cabrera field representative must wrap VOA bottles in bubble wrap and place a maximum of three wrapped VOA bottles into a plastic zipper storage bag. For each shipping container, sufficient cooling material is placed into the container (see next bullet), and the container is filled with plastic zipper storage bags of samples. The chain of custody form is to be signed by the person delivering the samples to the laboratory and the form is sealed into a plastic zipper storage bag and taped to the inside lid of the shipping container. Lastly, the container is taped shut and, if required, custody seals are placed on the container.
- If samples are to be shipped, it is extremely important that ice be packed in such a way the water from melting ice is prevented from leaking out of the coolers. Cooler drains shall be taped shut. A trash bag should be placed in the empty cooler before any samples or other packaging is used. Ice should be placed in a double layer (double bagged) of water-tight plastic zipper storage bags.
- For other types of samples and containers, the process is generally the same except that each sample bottle should be wrapped in a protective

layer of material and placed into separate, sealed plastic zipper storage bags, if possible.

- If the samples are very high concentration (total chemical concentration greater than or equal to 15 percent) and are to be shipped by overnight common courier, the use of shipment cans and vermiculite is required for safe transportation. Also note that labeling of these types of high concentration samples (cans and coolers) must comply with Department of Transportation (DOT) labeling requirements.
- The chain-of-custody should be placed in the cooler on top of any packaging. Protect the chain-of-custody inside a plastic zipper storage bag. If the cooler has been scanned, smeared and cleared for potential radioactive contamination, place a copy of the survey in the bag along with the chain-of-custody.
- Seal the cooler closed with packing tape. Apply orientation arrows and "Handle with Care" stickers on at least two sides of the cooler, along with two custody seals, intercalated within the layers of packing tape.

The figure below illustrates the above procedure. If any steps in this procedure do not apply to your situation or you cannot follow each step due to technical concerns, consult your local HAZMAT Shipping Specialist or OH&S Manager for additional details.

Environmental Sample Package / Label Example



The Cabrera field representative is responsible for properly and safely following the procedures presented in this section so that holding times are not exceeded, proper preservation temperatures are maintained during shipment (≤4°C per 40 CFR Part 136), and the samples are packaged so sample containers are not broken during transportation to the laboratory.

7.6 Sample Shipping

For shipment of samples, it is important to make the arrangements for transporting the samples to the laboratory before starting any sampling episode. If the samples are to be sent by overnight common courier, the prior arrangements include obtaining pickup service or determining where and when the samples can be dropped off. It may also be necessary to modify the sampling schedule to match the latest pickup/drop off times for overnight delivery.

For samples collected or shipped on Friday, Saturday, or Sunday, the Cabrera field representative should ensure that laboratory personnel will be present to accept the shipment. If sample coolers sit on a loading dock for a day or more sample integrity may be compromised as the ice melts. The project manager and/or the Cabrera field representative should also check with the laboratory to be used for the project and determine if they have a dedicated courier service. While there may be a fee for this service, in some circumstances this service will be the most cost-effective method of shipment.

If samples are to be shipped via FedEx or UPS, place address label with both the shipped from and ship to address on the top of the cooler. Complete standard airbill and attach to cooler. Maintain Sender's copy until samples have been received by the laboratory.

When shipping environmental samples, the transporter (Federal Express) may require a "NOT RESTRICTED" declaration to be completed by the shipper and ask that the package be labeled accordingly. These declarations can be completed providing that the package contains only environmental samples.

8.0 REFERENCES

- Cabrera OP-008, Chain of Custody
- Cabrera OP-391, HAZMAT/DG Shipping
- 40 CFR, Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants (2003)

9.0 REQUIRED RECORDS

- Chain-of-Custody forms
- Sample Control Log
- All field notebooks and/or sample documentation

10.0 ATTACHMENTS

Attachment A – Sample Tracking Log Instructions

Attachment A

Sample Tracking Log Instructions

Sample Tracking Log Instructions

The sample tracking log is an Excel spreadsheet that contains numerous linked cells. Employees that are expected to enter data into this form should be familiar with this procedure to ensure quality information.

1.0 Instructions Tab

The first page of the file presents detailed information on how to use the Excel tool.

2.0 COC Tab

The Cabrera office address and phone and fax numbers should be entered in column C, rows 1 through 3.

Enter the project specific information in column A, rows 5 through 8. This information typically includes:

- Project Name
- Project Number
- Cabrera Contact name, phone and fax numbers

Enter the analysis names (row 9) and methods (rows 5 through 8) needed in columns H through Q. It's best to group the soil analyses separately from the water analyses for the sake of clarity. The analysis names and method numbers will then be automatically updated onto the Sample Tracking Log.

The 'sample description', rows 10 through 34 of the COC, are to be pasted in from Columns B through Q of the Sample Tracking Log. Column A "Lab ID" is for the use of the lab and they will assign their own numbers in this column. The COC accommodates 25 samples on Page 1 and an additional 25 samples on Page 2. Make a copy of the COC spreadsheet for use the next day.

The COC has been set up in 'portrait' format rather than the customary 'landscape' format in order to accommodate more samples (see Figures in Section 23.0).

To print the COC, if you have more than 25 samples, simply select the 'Print' icon. If there are 25 samples or less, do not use the 'print' icon, but instead select '\File \Print…' from the drop-down menus, then print only Page 1 of the COC.
After the COC is printed, unused columns and rows are typically 'lined through' to prevent the addition of unwanted information. Cells can be 'lined through' in Excel by changing the 'fill color 'of the unused rows and columns to gray.

The COC must be printed twice in order to send the 'original' to the lab and to retain a copy for project records. If a copier isn't available, any handwriting made on the original must be exactly duplicated on the copy. Alternatively, if the only

handwriting needed on the COC is in the signature box, the COC may be signed digitally using Adobe Acrobat, then only one paper original needs to be printed, and the 'copy' can be saved digitally.

3.0 Sample Tracking Log Tab

The Sample Tracking Log is set up by entering the number of containers needed for each analysis type in Row 1 (these cells are shaded yellow). The analysis names are automatically entered from the COC.

Once in the field, enter pertinent data onto the sample tracking log. Enter the sample name and sample time, which must be entered in 'mm/dd/yy hh:mm' Excel format. Enter sample depths and codes for matrices as specified in the project work plans.

The total number of containers associated with each sample (Column F) is updated automatically. Associate duplicates with primary samples by typing in the row number of the duplicate into Column T of the primary sample row – vice versa for the duplicate sample row. Associate trip blanks and rinse blanks by typing in the row numbers for these blanks into Column T of every pertinent primary and field duplicate.

Enter the sampler's initials into column G. Then select which analyses will be performed by placing an 'X' in the appropriate column.

4.0 Labels (On and Off-Site) Tabs

Labels have been formatted to print onto 2" x 4" shipping labels using a label printer. This type of label is thermally-printed and therefore water-resistant. A label printer has advantages over laser printers in that only the labels needed are printed, and they can be printed in the field instead of in advance of field work.

The 'label' tabs have been set up to print all of the labels needed for a single row of information entered onto the sample tracking log. Contents of the sample tracking log are automatically pasted into Row 3 of the 'label' tab, starting at Colum K. The 'container' and 'preservative' information are set up to be automatically pasted from the 'reference' tab. One can simply type this information directly, if desired. Bar-code information is updated automatically. The bar codes are in Code 39 format and are intended to be used by the lab to reduce data transcription errors.

To print a label, enter the number from column A on the Sample Tracking Log corresponding to the sample one wishes to label into cell F3 (which is shaded green) on the 'label' tab. The sample information is then entered automatically onto the label. For the Dymo LabelWriter 400 printer, select 'landscape'. For paper size, select the no. 30323 'shipping label'.

5.0 Reference Tab

An 'analysis summary' should come from the project FSP or from the client's Scope of Work. The Reference tab contains an example of a typical analysis summary list, which includes the analyses, analyses methods, sample containers, preservatives, and hold times. The project specific analysis summary should be pasted into the Reference Tab (see Figures in Section 23.0) replacing the example. It is also acceptable to adapt the example to reflect the project requirements.

The analysis type, container and preservative are used on the sample labels. The workbook links some of the label cells to the reference cells, so be very careful that the appropriate cell is linked before printing off the labels.

CABRERA SERVICES
RADIOLOGICAL • ENGINEERING • REMEDIATION

OPERATING PROCEDURE

FOR

PREPARATION OF SAMPLES FOR GAMMA SPECTROSCOPY

OP-428

Revision 1
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1.0 PURPOSE

The purpose of this Operating Procedure (OP) is to provide Cabrera Services Inc. (Cabrera) personnel with the method for preparation of soil samples for gamma spectroscopic analysis. Drying and homogenization assures that the analyses performed have accurate and reproducible results.

2.0 APPLICABILITY

This procedure applies to all Cabrera employees and operations. Personnel shall utilize this procedure to prepare soil samples for quantitative analyses at customer facilities unless specified otherwise through the project specific Field Sampling Plan (FSP), or Quality Assurance Project Plan (QAPP). Personnel must assure that the specifications of this OP agree with the specifications listed in the Project Work Plans.

3.0 DEFINITIONS

3.1 Project Plans - For the purposes of this procedure, a generic term describing the project implementing plans that contain the information associated with the requirements for mandated sampling. These include, but are not necessarily limited to:

3.1.1 Project Work Plan (PWP) - The over-arching project plan used to manage both project execution and project controls. A primary use is to document planning assumptions and decisions including quality assurance and quality control (QA/QC) measures regarding data gathering and deliverables.

3.1.2 Field Sampling Plan (FSP) - Provides specific directions for conducting each separate field sampling activity and presents the rationale and design, for the work, as well as the field procedures for each specific activity required. Field operations and documentation are also described and may include discussions on field logbooks, photographic records, sample documentation, field analytical records, and procedures for their management and retention.

3.1.3 Quality Assurance Project Plan (QAPP) - Focuses primarily on the analytical methods and QA/QC procedures that are used to analyze and manage environmental samples and their resulting data. The QAPP also presents the project organization, objectives, procedures, functional activities, and specific QA/QC activities associated with sampling, data management and record retention.

3.1.4 Site Safety and Health Plan (SSHP) – Provides evacuation routes for the site and immediate area; site-specific safety information; a Chemical Hygiene Plan for laboratory operations which will include

Safety Data Sheet (SDS) for any relevant chemicals of concern; and names and telephone numbers of common emergency contact personnel for the worksite. In addition, the SSHP may also contain sampling activities required to monitor worksite safety and health.

3.2 Quality Assurance (QA) - All procedures, practices, records, and other documentation required to provide confirmation that project activities are completed in a manner compliant with regulations, specifications, and/or contract requirements.

3.3 Quality Control (QC) - For the purposes of this procedure, actions taken to control the variable attributes of the sampling and analytical processes to meet the data quality objectives described in the project plans.

3.4 Sample Tracking Log - A quality control form that lists all of the samples collected, list the analyses to be performed, and tracks their destination

3.5 Chain of Custody - The Chain of Custody lists and describes a shipment of samples that leave the custody of the sampler and are transferred to the custody of the laboratory. For additional information, please refer to OP-008, Chain of Custody.

3.6 Work Instruction (WI) – Provides manufacturer's model specific instructions for the use of a specific piece of equipment.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

Highly organic soils and soils containing oil or other contaminates may ignite into flames during microwave drying. A means for smothering flames (i.e. Class A,B,C, fire extinguisher or fire blanket) to prevent operator injury or oven damage should be available during drying. Fumes given off from contaminated soils or wastes may be toxic, and the oven should be vented accordingly. Please consult with the Site Safety and Health Officer (SSHO) to ensure adequate precautions are in place prior to operations.

All samples should be stored/maintained in a location with adequate ventilation. Samples having significant volatile organic compound (VOC) or semi-volatile organic compound (SVOC) concentrations can slowly release vapors into a confined space over time such that local concentrations may exceed action limits. The necessity for air sampling and/or respiratory protection during sieving and drying soil samples should be evaluated prior to commencing work.

Soil samples can reach high temperatures when drying. Steam and high temperature water vapor may be vented from the microwave oven during the drying process. Appropriate precautions (i.e. oven mitts) should be taken when

handling samples, opening microwave oven door etc. Liquids heated in a microwave oven can become superheated and cause serious injury. If a heat sink is used, caution should be taken in handling it.

Do not suspend lamps from the power cord unless designed for that type of suspension.

4.2 Limitations

Samples must be produced to match as closely as possible the geometry for which the gamma spectrophotometer has been calibrated (e.g. the density of the samples should be as close as possible to the density of the calibration source).

Gamma spectroscopy containers are generally not reusable due to the possibility of cross contamination of samples. If reusable soil handling implements are used, they must be thoroughly cleaned between samples to minimize cross contamination.

4.3 Requirements

Personnel handling radioactive material are trained in accordance with Cabrera's administrative procedure; AP-009, Training, and will adhere to appropriate precautions.

Personal protective equipment shall be worn in accordance with Cabrera OP-561, Personnel Protective Equipment, and site specific requirements during sample collection and handling, as designated in the project plans.

Refer to OP-468, Sample Management – Onsite Laboratory, for the requirements associated with the management of samples in the lab, and OP-362, Sample Management and Shipping, for the requirements associated with proper sample numbering and tracking.

All samples are to be handled by as few people as possible and the chain of custody form must document the change of possession by the appropriate dated signatures.

Field Personnel shall discuss deviations to the Project Work Plans with the Project Manager. Any deviations, plus conversations with the PM, shall be documented in the project field notebook.

5.0 EQUIPMENT

- Sample Containers (e.g. Marinelli beakers) with lids
- Spoons, spatulas, bowls and other soil handling implements (disposable or re-usable)

- Soil Processor / Grinder
- Laboratory coat and safety glasses
- Hearing Protection (Soil Processor Operation)
- Down Draft Table with HEPA Filtration
- Vacuum Cleaner with HEPA Filtration
- Custody seals
- Sample tracking log
- Field notebook
- Secured staging area with appropriate ambient temperatures, ventilation, and access controls

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) - The PM is responsible for implementing and ensuring compliance with the contents of the project plans. They also must ensure that project personnel have been trained and are qualified to implement this procedure.

6.2 Laboratory Manager - The Laboratory Manager is responsible for the overall management of environmental samples brought into the onsite laboratory for analysis, to include; the logging, tracking, storage, archiving and disposal of the sample.

6.3 Site Safety & Health Officer (SSHO) – The SSHO is responsible for coordinating the appropriate safety measures necessary to ensure that adequate controls are in place for the hazards presented by this operation, including potential chemical and/or radiological exposure to employees during the sample drying and grinding process.

6.4 Project Personnel - All Cabrera personnel are responsible for reading, understanding, and complying with the provisions of this procedure prior to engaging in sampling activities. In addition, site workers should discuss any deviations from the prescribed sampling protocols with the PM or FSM, and document that conversation in the project field notebook.

It is the responsibility of the sample preparation personnel to review the manufacturer specific WI or operating instruction manual for operation of the sample processor / grinder and the downdraft table.

7.0 PROCEDURE

Soil samples are dried and sieved per OP-426, Drying Soil Samples by Microwave Oven. The dried sample is ground to ensure homogeneity between samples and ensure consistency in measurements. The samples are then weighed and sealed to provide the data necessary for quantitative analysis.

7.1 Drying the specimen

Soil samples should be dried and sieved under Cabrera OP-426, Drying Soil Samples by Microwave Oven. When microwaves are not available, conventional means, such as muffle ovens, convection oven, heat lamps, etc. may be used to dry soil samples.

7.2 Soil Processing

The dried, sieved sample produced by OP-426 shall be ground and collected in a tared container. All soil processing will be performed on a properly operating downdraft table. It is the responsibility of the sample preparation personnel to review the manufacturer specific WI or operating instruction manual for operation of the sample processor / grinder and the downdraft table. General processing steps are outlined below.

7.2.1 Place a tared collection vessel under the processor outlet. The container used to collect the sample may be the same container used for gamma analyses.

7.2.2 Introduce the soil into the processor hopper in small increments.

7.2.3 Operate the processor and collect the sample in the tared vessel.

7.2.4 Repeat processing sample until sufficient sample is collected for gamma spectroscopy preparation.

7.2.5 Ensure the soil is well settled into the container by lightly tapping the container. DO NOT pack or compress the soil into the container.

7.3 Record Weight of Specimen

Sample weights may be determined under Cabrera OP-427, Operation of Digital Laboratory Balances. The basic steps are as follows:

7.3.1 Note and record the sample number on form OP-426, Attachment A, Soil Sample Drying Record.

7.3.2 Weigh the sample container, note and record the tare weight (or use the tare feature of the scale).

7.3.3 Place the sample into the container. The soil should fill the container. Consult project Technical Lead (TL) for sample volume requirements, as minimum volumes may be required to achieve project-specific goals and to match the geometry, as stated in Section 4.2, Limitations.

7.3.4 Note and record the gross weight and compute the net weight of the sample, or use the tare feature of the scale to determine the net

weight. Record the net weight of the sample in the comments section of the CoC and on the Soil Sample Drying Record (OP-426, Attachment A).

7.4 Final Preparation of Specimen

Seal and label the sample container. The sample label should include sample name, sampling date, preparation date, and sample weight. Ensure the chain of custody form is maintained per accordance with OP-008, Chain of Custody, and OP-362, Sample Management and Shipping.

7.5 Decontamination

Use a Hepa filtered vacuum clean to clean the downdraft table and soil processor. Wipe down the table with towel wipes and perform a radiological survey prior to using the equipment again.

8.0 REFERENCES

- Cabrera OP-008, Chain of Custody
- Cabrera AP-009, Training
- Cabrera OP-362, Sample Management and Shipping
- Cabrera OP-426, Drying Soil Samples by Microwave Oven
- Cabrera OP-427, Operation of Digital Laboratory Balances
- Cabrera OP-561, Personal Protective Equipment

9.0 REQUIRED RECORDS

- Chain-of-Custody forms
- Sample Tracking/Control Log
- Soil Sample Drying Record (OP-426, Attachment A)
- All field notebooks and/or sample documentation

10.0 ATTACHMENTS

None.

CABRERA SERVICES
RADIOLOGICAL · ENGINEERING · REMEDIATION

OPERATING PROCEDURE

FOR

GAMMA SPECTROSCOPY OPERATIONS

OP-429

Revision 5.0

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1.0 PURPOSE

This operating procedure provides instruction and requirements for the operation of Cabrera Services Inc. (CABRERA) gamma spectroscopy systems for laboratory or in-situ applications. It describes advanced measurement and analysis methods to perform gamma emissions analysis of volumetric samples using high resolution intrinsic germanium gamma spectroscopy, Canberra Industries' GENIE-2000 software version 3.2.1, and Geometry Composer software up to Version 4.2.1.

2.0 APPLICABILITY

This procedure is applicable to personnel who set up, operate, and maintain CABRERA gamma spectroscopy equipment. Instructions, in this procedure, apply to:

- Equipment Setup
- Routine instrument operation
- Quality control measurements
- Spectrum file management

This procedure supersedes OP-029 (Rev 4.0)

3.0 DEFINITIONS

3.1 Full Width at Half Maximum (FWHM) – The width of a single spectrum peak at one half of its centroid height.

3.2 Gamma Acquisition and Analysis (GAA) – The acquisition portion of the Genie 2000 software package that controls detector functions.

3.3 High Purity Germanium (HPGe) – A germanium semiconductor photon detector used to detect gamma and X-rays.

3.4 In-situ Object Counting System (ISOCS) – A system whose software and hardware components are utilized to detect and quantify radioactive gamma emitting nuclides.

3.5 Multi-Channel Analyzer (MCA) – An electronic instrument that segregates pulses received by the detector into various bins based on the pulse magnitude.

3.6 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 When in the presence of radiological material, ALARA measures will be used to minimize the potential for contamination and unnecessary dose.

4.1.2 HPGe detectors are susceptible to physical damage, and care should be taken to avoid dropping or hitting the equipment. Front windows of germanium detectors are very fragile and placing or dropping the sample on it may cause it to break making the detector inoperable.

4.1.3 The instruments are susceptible to water/moisture damage and should only be operated in wet environments when appropriate protective precautions are implemented. The instruments should not be operated in very wet environments such as heavy precipitation.

4.1.4 The detector systems utilize a high voltage. Use caution when handling cables and other electrically powered elements of the systems; ensure elements are powered down before unplugging.

4.1.5 Avoid skin contact with liquid nitrogen (LN_2) to avoid frostbite. When handling LN_2, always use proper eye and skin protection, including cryogenic safety gloves, safety glasses and/or a face shield.

4.1.6 The shielding for the detectors is comprised of painted lead. If the shielding gets scratched or cracked, alert the Safety Officer and take the necessary precautions, as directed.

4.1.7 The detector systems can be extremely heavy. Therefore, take care to watch for pinch points when lifting or moving parts of these systems – particularly when opening and closing laboratory shields.

4.1.8 When transferring LN_2 from one Dewar (container) to another or venting LN_2 using pressurized air or gas, ensure there is proper ventilation of the area.

4.1.9 Be aware of potential explosion hazards that may exist. Liquid nitrogen expands over 700 times when converting from the liquid to gas phase, at room temperature. Therefore,

- Never seal the vent tubes on the end of the Dewar of the HPGe detector.
- Never seal a container holding LN_2.

4.1.10 When a cryostat exhibits signs of vacuum failure (e.g., heavy moisture or ice formation on the surface or extremely high LN_2 loss rate), stop using the unit immediately. Notify the CABRERA Project Manager and contact the Subject Matter Expert (SME) or Health Physicist for further instructions.

4.1.11 Refer to equipment manuals for additional information on maintaining, storing, moving, and shipping instructions.

4.2 Limitations

4.2.1 The instrument will not be operated in environments where the ambient temperature exceeds 40° C or is less than 5° C (104° F and 41° F, respectively).

4.2.2 Qualifications – There are three levels of gamma spectrometry users: Gamma Spectrometry Operator 1, Gamma Spectrometry Operator 2, and Subject Matter Expert. Requirements and qualifications for each level are included in Attachment A. Responsibilities given to personnel should be restricted to their qualifications.

4.2.3 Training – Initial training for each level is scheduled by the NDA group, as needed, and certification is issued upon successful completion of each level. Requirements for re-certification of each level are provided in Attachment A, and must be obtained no later than 2 years from the previous (re)certification. Responsibilities given to personnel should be restricted to their qualifications.

4.3 Requirements

4.3.1 Personnel handling radioactive material are to be trained in accordance with CABRERA'S administrative procedure, AP-009 Training, and take all appropriate precautions, as listed above.

4.3.2 Energy calibrations and/or gain adjustments will be performed, as stated in this procedure, to ensure that the accuracy of measured results is not compromised.

4.3.3 Authorization and guidance, from the SME or Health Physicist, is required prior to warming the germanium detector to room temperature.

CAUTION

Bias voltage will NEVER be applied to a warming or a warmed-up germanium detector!

4.3.4 Prior to refilling the Dewar, ensure that the outlet of the tubing connecting the LN_2 cylinder to the detector's Dewar is clear of dirt.

4.3.5 No adjustments will be made to the detector high voltage unless authorized by a Health Physicist or SME. HPGe detector and MCA settings will be setup by, or with the assistance of, an SME prior to, or at the beginning of, the project. Creating or editing parameters should not be done without an SME and may void collected data.

4.3.6 Prior to reuse, you must ensure that all sample containers (i.e., Marinelli beakers, etc.), tools, etc. are clean and dry. Wash all items to remove any trace of previously contained sample material. Any items that will not clean adequately must be discarded (as per the Laboratory Manager) to prevent reuse and the possibility of cross-contamination.

5.0 EQUIPMENT

5.1 For use with LN_2

- Tank containing low (~22psi) pressure LN_2
- Transfer Dewar flask/Big MAC (multi-attitude cryostat) Dewar flask
- Metal connection hose
- Rubber tubing with clamps (optional)
- Adjustable crescent wrench (~12”)
- Face mask
- Apron
- Cryogenic gloves

5.2 For use with Detector

- Dewar flask (for lab systems)
- Composite cable
- Detector specification sheet
- Allen wrench (7/32”)

5.3 For use with MCA

- DSA-1000 or InSpector 2000
- USB cable
- USB hardware key (for DSA-1000 only)

5.4 Shield

- For lab units, this consists of a lead table and stackable rings with a sliding door on top.
- For In-Situ Object Counting Systems (ISOCS), this consists of a shield set: (4) annular shield rings (25 mm or 50 mm thick), steel spacer tubes, clamp screws, and detector clamps.
- Standard/Philips screwdrivers

- Standard/SI Allen wrench sets.

5.5 Uninterruptable Power Supply (UPS), conditioner and a digital voltmeter (optional)

5.6 Computer with:

- GENIE 2000
- ISOCS Geometry Composer software
- Printer
- USB Flash Drive
- Extension cords with surge protectors
- Bound Logbook

5.7 ISOCS may also require the use of the following equipment (actual list will vary depending upon need):

- Detector Tripod
- Detector Cart
- Extra-long signal cable
- Source jig for daily QC measurements

6.0 RESPONSIBILITIES

6.1 Health Physicist (HP) – Responsible for developing, revising, and implementing this procedure. Trains and qualifies SMEs based the on minimum training and experience requirements of CABRERA's NDA Qualification Program. They ensure that analytical data are verified only by technically qualified personnel who are independent of performing those analyses.

6.2 Subject Matter Expert (SME) - SME qualification is synonymous with the Expert Analyst level, as defined by the US Department of Energy; and, is responsible for:

- Training and qualifying gamma spectrometry operators based on minimum training and experience requirements, as listed in Attachment A.
- Providing guidance to operators and HPs, as necessary, and making recommendations to CABRERA upper management concerning program quality.
- Acting as the primary point-of-contact for equipment upgrades, software, and repair service relating to all gamma spectrometry systems.
- Ensuring that the detector and system are operating properly, which includes

ensuring the detector is filled with LN_2 and monitoring QC charts.

- Providing guidance, oversight, review and approval of: data acquisition; data reduction; geometric modeling; and final reporting of gamma spectrometry measurements.
- Preparing operating procedures, or technical documents, for specific project tasks.
- Defining analysis templates and executing data analysis algorithms to develop data reports.
- Developing and documenting source model and Monte Carlo efficiency files.
- Correcting deficiencies and nonconformances identified for project tasks.

6.3 Gamma Spectrometry Operator – is responsible for:

- Ensuring that the ISOCS equipment is calibrated and the QC spectrum is within control limits.
- Performing instrument calibrations, under direction of the designated SME, and taking all measurements including QC measurements.
- Evaluating measurement results and generating reports.
- Communicating problems or discrepancies encountered with filling or operating the detector to the SME.
- Reviewing instrument QC charts and notifying the SME of nonconformances and/or corrective actions required.

7.0 PROCEDURE

7.1 Setup Preparation

7.1.1 Initial setup will be performed, or directly supervised, by qualified personnel under the guidance of SMEs or Health Physicists.

7.1.2 During setup of the system, manufacturers' safety precautions should be reviewed and followed. Refer to the Detector Specification Sheet, Canberra's System User Manual, and/or other relevant system manuals for complete instructions.

7.1.3 The gamma spectrometry system should be placed in a location that minimizes vibration, electro-magnetic and radio frequency interferences. The location must provide adequate ventilation and temperature consistency.

Note: Ensure that the MCA is plugged into a power conditioner at all times. Power to all system components (except an external monitor) should also be protected by an UPS in the event of loss of offsite power.

Note: The UPS should be a quality UPS capable of producing a filtered RMS (root mean square) voltage with the ability to maintain a consistent and constant voltage in the event of an over or under voltage condition.

7.1.4 Initial LN_2 fill:

- Before attempting to fill the Dewar with LN_2, ensure all LN_2 connections are made correctly. In addition, an extension should be added to the vent tube, of sufficient length, to direct cryogenic gases away from personnel and equipment.
- Connect the LN_2 fill hose using either the 1/8 pipe thread fittings or a flexible latex hose stretched over the port fittings.
- A Big MAC Dewar may be filled using multiple arrangements – flat, up-looking or down-looking. There are two fill/vent ports on the back of the MAC Dewar. Make sure to use the appropriate fill port for the orientation of the detector, per the diagram attached on the back of the Dewar. If a fill/vent diagram is missing, contact the SME immediately prior to filling with LN_2.
- When filling the detector (Big MAC) Dewar with LN_2, ensure delivery of liquid is at pressures between 5 psi and 25 psi.
- When using a large, stationary Dewar (30-liter) with a dip-stick (7500SL) type detector, direct the vent tube into an appropriate overflow container. If you don't have an overflow container, make sure the vent side is clear of any personnel or equipment.
- If using a secondary transfer Dewar, complete the initial fill of a 30L stationary Dewar as transfer may take several iterations to complete. Please refer to Section 7.17 for specific instructions on how to properly use transfer Dewars.
- SLOWLY open the valve on the supply source of LN_2 and gradually increase the flow of the LN_2 to fill the Big MAC until liquid is seen exiting the vent side connector in a steady stream (not spurting). Be careful to avoid contact with LN_2. Close all connections and, after it has had a chance to warm up, remove the fill hose.
- Prior to applying high voltage, the detector should be allowed to cool for a sufficient time. This will be at least 6 hours for a typical detector, although minimum cool-down times will be stated on each detector's specification sheet. A 12-hour cool down period is recommended to ensure the system reaches a complete thermal equilibrium.
- When using a Big MAC Dewar for laboratory counting purposes, ensure that the Dewar is sitting on a lift mechanism, or a custom wood platform, that properly raises the detector above the shield table to an appropriate height. Initial filling of the Dewar, with LN_2, may be performed outside of the collimator, as per normal filling procedures.

- Place the Dewar in the collimator in the up-looking position, on the supplied Dewar stand, and ensure proper LN_2 connection is made. When finished, disconnect the fill hose from the Dewar, ensuring that the vent cap is placed in the appropriate position based on the vertical arrangement of the detector, otherwise LN_2 leakage will occur.
- Occasionally, a thermal cycle of the detector will be needed in order to recover resolution performance. When a warm-up cycle has begun, the detector will be allowed to completely warm up to room temperature before being cooled down again (this is a period of approximately 24 hours). This allows different components, within the cryostat, to reach thermal equilibrium. Otherwise, resolution performance may degrade if the thermal cycle is done improperly. Resolution can be recovered with a consequent thermal cycle.

WARNING

If heavy condensation or frost formation is seen on the outside of the detector enclosure, this is indication of vacuum failure within the detector. Stop using the unit immediately and turn the detector bias HV off, if it is not off already. Notify the SME for further instructions.

7.2 Detector Mounting

7.2.1 During system set-up, manufacturers' safety precautions for equipment set-up should be reviewed and followed.

7.2.2 The HPGe system should be stored and used in a location that minimizes vibration, electro-magnetic and radio frequency interferences. Interference can also be kept at a minimum by preventing other items from using the same power supply.

7.2.3 Orient the fill/vent end cap, on the Dewar, to the proper orientation depending on actual field use.

7.2.4 Move all necessary system hardware to the desired storage or measuring location, including: the detector, laptop computer, MCA (InSpector 2000 or DSA1000), connecting cables, and ISOCS shield components (if used).

CAUTION

Detector entrance windows are extremely delicate (carbon fiber and beryllium are the most common examples). When the detector is not in use, always place the plastic protective end-cap over the end window.

7.2.5 **IF** the detector is to be used with a standard Canberra rolling cart or a customized hydraulic lift cart, **THEN** follow Steps 7.2.6 through 7.2.9. **IF** the detector is to be used with a tripod, **THEN** skip to Step 7.2.10.

7.2.6 Securely mount the detector to the ISOCS, or lift cart, in the desired position relative to the object of interest. Take care that the detector is not sitting on top of the cables. A diagram showing the assembly of an ISOCS shield set is provided as Attachment B.

7.2.7 Mount the rear lead shield and appropriate collimators. The ‘’New’ collimator set requires screw mounting of the rear shields to the detector carriage assembly. The ‘Old’ collimator set has hand screws that attach one-half of the rear shield to the other half without the need for other tools.

7.2.8 Set the detector collimator inset to approximately 2 millimeters. This is the distance from the detector window to the edge of the outside lead collimator. This inset is part of the detector modeling protocol and must be verified; however, it should not change after setup.

7.2.9 Proceed to Section 7.2.14

7.2.10 Anchor the tripod leg tips firmly in the ground. If the tripod is to be used on hard surfaces, place rubber stopper covers on tips. Secure the legs with restraints.

Note: If the leg angle is greater than 30 degrees from vertical, or the tripod is being set on a paved or other hard surface, a rope or chain should be used to prevent splaying and collapse of the unit. The rope or chain can be threaded through the metal loop on the inside of each leg tip and secured to keep legs from splaying.

7.2.11 Adjust the legs to provide a level surface at the appropriate height. A bubble level is mounted on the platform to help with leveling. A plum-bob is available which, if hooked to the plastic hinge at the leg/platform interface, helps in setting the detector at the desired distance from the ground.

7.2.12 Gently lower the detector into place on the platform, observing the orientation of the cables. The MAC carrier should be flat against the top of the platform.

Note: Make sure the cam-lock knobs on the top of the tripod platform are aligned so that they do not interfere with the detector carriage when being placed on the platform.

7.2.13 Secure the MAC carrier, to the top plate, by twisting the cam-lock knobs ninety degrees.

7.2.14 Once the proper amount of cool-down time has elapsed, connect the detector cable from the preamplifier (a.k.a. preamp) to the MCA. The preamp is the small black box mounted on the top side of the detector assembly. The MCA is connected to the preamp via a composite cable (model C1725). It is easier to connect the HV Inhibit cable first. The cable ends are typically marked as to which connector they should be attached. Verify the preamp-to-MCA cables are connected and are in good condition. If the system will be used with 110-volt power, connect the power adapter plug to the MCA.

7.2.15 See Section 7.3 to set-up the power supply. Once the power supply is properly set-up, turn the MCA on by pressing the switch on the side (for the InSpector) or the back (for the DSA) and start the computer and Genie2000 Gamma Acquisition and Analysis program. Verify that the center LED on the preamp is green (labeled HV Inhibit). This verifies that the detector has been properly cooled and that HV may be applied. If this LED is NOT green, DO NOT apply HV. Contact the SME for further instructions.

7.2.16 Connect the “square” USB connector to the MCA and connect the flat end of the USB connector to the computer USB port.

7.3 Power Sources

7.3.1 Field *in-situ* gamma spectroscopy systems may be operated using a variety of power options. The configuration most frequently used is a 12-volt DC car battery with an AC inverter. It is recommended that, if available, nonacid-based, deep-cycle marine batteries be used for this purpose. This arrangement provides a clean source of power with a full charge lasting 8-12 hours.

7.3.2 An inverter may also be plugged into a vehicle’s DC power supply port. However, be careful that the power of the inverter (e.g., 400 Watts) does not exceed the recommended power output of the DC supply port. Exceeding this power level may cause fuses to blow in your vehicle.

7.3.3 It is recommended that a camcorder battery be loaded on the back on the InSpector 2000, as a backup, in case external power is lost. This may prevent sudden loss of data.

7.3.4 If direct AC power is available for the field job being performed, use a UPS unit with battery backup with each system.

7.3.5 Try to avoid excessive use of extension cords (greater than 50-feet) unless the cords provided are 12-gauge wire or larger to avoid a voltage drop, in the cord, over long distances. Excessive voltage drop can damage electronics!

Note: Wire conductor size increases as gauge decreases. For example, 12-gauge wire has larger diameter conductors than 16-gauge wire. The lower the gauge, the less voltage drop will occur.

7.4 Setup of Data Folders on a Computer

7.4.1 Create the proper file structure on the gamma spectroscopy computer system in the Project Folder, on the Lab computer, if one has not already been created.

7.4.2 If a project does not already have the desired file structure in place, then the suggested Windows file structure to be used. During CABRERA projects, for files related to the gamma spectroscopy laboratory, the file structure is as follows:

- Folder Level 1 – "XYZ Site Gamma Laboratory" – The first folder will be named as the Project Name and then Gamma Laboratory (example name is provided). Within this folder, will be a second level folder, as follows:
- Folder Level 2 – "CNF Files" – Files saved in this folder will be sample measurement (.cnf) files. These files will be named using the naming convention setup for the project. These files will need to be manually copied from the C:\GENIE2k\Camfiles.
- Folder Level 2 – "Quality Control" – Files saved into this folder will be (1) The Quality Assurance Editor File for the project (.QAF); and (2) daily QC measurement (.cnf) files. The daily QC measurement files will incorporate the date and follow the naming convention: qcmmddyy.cnf (e.g., for a QC source measurement performed on January 1, 2013 the file would be qc010113.cnf). If more than one QC measurement is collected in one day, then suffixes will be used a, b, c, etc. (e.g., "qc010113a.cnf"). Within this folder, will be third level folder, as follows:
- Folder Level 3 (inside QC folder) – "Initial Measurements" – Files saved in this folder will be the ten initial source measurement (.cnf) files collected to setup the system QC trending.
- Folder Level 2 – "Reference Files" – Miscellaneous reference files related to the gamma spectroscopy laboratory may be saved in this folder.
- Folder Level 2 – "RPT Files" – Files saved into this folder will be sample report (.rpt) files auto-generated by the Genie-2000 software. These files will need to be manually copied from the C:\GENIE2k\Repfiles folder.

7.4.3 Place a Windows 'Shortcut' to the On-site lab Folders on the Desktop of the Lab Computer

7.5 Initial Detector Setup

The following steps outline the initial setup and testing of a gamma spectrometry detector system:

7.5.1 SME will:

- Verify correct HV polarity settings of the detector and MCA prior to application of the detector bias.
- Verify the initial setup of the field ISOCS computer and detector.
- Review the field notebook, or appropriate project specific forms and/or documentation, daily and sign.

7.5.2 Operator will:

- Verify that MCA high voltage polarity, in the detector MID file, matches the polarity setting within the MCA (InSpector 2000 or DSA-1000). Reverse Electrode (REGe) detectors require negative bias (i.e., -3500 V); Broad Energy (BEGe) detectors require positive bias (i.e., +4000 V). If the high voltage polarity needs to be reversed, consult Section E of the 1300 InSpector 2000 Hardware Manual for instructions.
- Verify the preamp-to-MCA cables are connected and are in good condition.

CAUTION
Ensure that high voltage inhibit cable is labeled and connected correctly in order to prevent fatal damage to a detector during a warm up if the high voltage is still on.

- Connect the square USB connector to the MCA and connect the flat end of the USB cable to the computer USB port. If the system will be used with 110V power, connect the power adapter plug to the MCA.
- Turn on the MCA by pressing the on/off switch on the side or back of the MCA. Turn the computer on.
- Open the GAA software by double clicking on the GAA icon on the desktop.
- Select <File> <Open Data Source> and select <Detector>.
- Verify that the desired detector is available for loading. All detectors loaded into the MID run-time database will show up in the Detector Data Source dialogue box with a magenta & yellow “Radiation” symbol next to the label. If the desired detector does not appear in the dialogue box, check the on/off switch on the MCA first, followed by power connectors or battery status. If necessary, seek assistance from the SME.

CAUTION

DO NOT attempt to apply HV if the HV Inhibit LED is Amber!

Wait an additional period of time to allow proper cooling or contact the SME for assistance.

- Press <MCA> <Adjust> to display the Hardware Control dialog box.
- Check the label on the detector and verify that the correct HV and polarity agrees with the settings for the detector you are using.
- Select <HVPS>. Verify the HV is the correct voltage and polarity before turning on the HV. If correct then press <ON>. The screen will display the High Voltage Control dialog box “Waiting” and the “Rate” light on the preamplifier will temporarily illuminate amber.

  Note: Turning on the HV takes approximately 45 seconds to complete as the voltage is slowly raised by the MCA. The word “wait” will appear in the HV MCA adjust dialog box. When ready, the system will return to the Hardware Control (MCA>Adjust) menu.
- Wait a minute after HV is applied to allow system to stabilize.
- Switch to the amplifier “Gain” adjustment tab.

  Note: Prior to the start of each counting session, the system energy alignment will be checked. If the gain of the target peak is outside of ±0.3 keV, THEN the gain must be adjusted.
- Place a suitable check source near the detector, during spectrum data acquisition, to check and adjust the amplifier gain settings.
- Allow the peaks to grow in, for a suitable amount of time, and in the GAA screen, place the markers on each side of the peak.
- Adjust the vertical full scale of the displayed spectrum and use the <Expand On> button, as appropriate, to view the reference photopeaks.
- Click <Acquire Start> from the MCA window and note the position of the photopeaks in the spectrum (specific to the source being used).
- Use the <Marker Info> dialog box, at the bottom of the spectrum window, to compare the calculated centroid channel(s) and corresponding energy value(s), for each reference photopeak, with their expected values. Observed photopeak centroids should typically be within ± 0.3 keV of their expected energy values.
- If necessary, amplifier gain settings can be changed by selecting <MCA><Adjust> and clicking on the “Gain” tab.
- Use the scroll bars in the Amplifier Fine or Super-Fine (S-Fine) gain

sections, of this dialog box, to make the appropriate changes. Bear in mind that changes to the 'Fine' gain will make far broader changes. After each change, clear any previous spectrum data and start a new acquisition to evaluate the new settings.

- When spectrum data acquisition indicates that the centroid channel, of each reference photopeak(s), is within ± 0.3 keV of the expected energy(ies), the new settings are deemed acceptable.
- Select the <Exit> button to exit the Adjust dialog box.
- Save the new parameter values by selecting <File><Save>, from the File menu, or clicking the disk icon in the top toolbar. This saves the new detector settings to the detector file.
- Document any changes in the field notebook or appropriate project specific forms and/or documentation.
- Once the spectral gain is corrected and stable, perform the Daily QC measurement, as prescribed in Section 7.11.8.
- If routine gain adjustments will not correct spectral misalignment, an energy recalibration may be required. Energy recalibrations may only be performed with the concurrence of a SME.

7.6 Initial Energy Calibration Check

Note: If a refresher is needed on the Gamma Acquisition and Analysis (GAA) program, please refer to Section 7.18 for a primer on Canberra's Genie 2000 software.

7.6.1 Place the check source provided, with the detector in front of the endcap, and start a count. The count time is arbitrary, but make it long enough so that you can see the various peaks growing into the spectrum.

7.6.2 Compare the positions of the known peaks, from the sources, to the actual locations shown on the screen. A few common check source peak locations are:

Cd-109	88.0 keV
Cs-137	661.6 keV
Co-60	1173, 1332.5 keV
Eu-152	121.8, 964, 1112, 1408 keV
K-40	1460.8 keV

7.6.3 Evaluate the accuracy of the peak locations both: (a) on a peak by peak basis, and (b) with regard to the linearity of the MCA from low energy to high. This will determine whether the system requires only a gain change or a full energy recalibration. Consult with the SME or Health Physicist on how to proceed based on this information.

7.6.4 If an energy calibration is not required, then skip to Step 7.8.

7.7 Energy Calibration (by nuclide list or certificate)

7.7.1 The steps for the Operator are:

- Remove the plastic end cap protector from the detector.
- Place the bottom of the source, on the face of the detector, centering it on the entrance window. Be very careful not to damage detector front window.
- Acquire a spectrum with a count time long enough to acquire several thousand counts in each of the various peaks growing into the spectrum.
- Evaluate the accuracy of the peak locations on a peak by peak basis. This will determine whether the system requires only a gain change or a full energy recalibration. Consult with the SME on how to proceed based on this information.
- **Energy calibration by Certificate File**:
    - Collect source spectra for a minimum of 10 minutes.
    - Select <Calibrate> and press <Energy>, then press <By Certificate File>. The “Open Certificate File” window will open.
    - Select the appropriate certificate file (e.g., Cabrera NIST #1263-8-3.CTF or that provided by the SME), then click <Open>. The “Energy Calibration – Full” window will open.

    Note: You must have a spectrum with at least three identified peaks and preferably at widely spaced energies.

    - **IF** the peaks are close, click the <Auto> button. The peak information will populate in the window.
    - **IF** the peaks appear to be substantially off, highlight a radionuclide of interest on the left side of the “Energy Calibration – Full” window, **THEN** place cursor on that peak, in the Gamma Acquisition window, then click on the <Cursor> button. Continue until all peaks of interest are identified.
    - Click the <Show> button. The “Energy Calibration Curves” window will open.
    - Evaluate the accuracy of the energy calibration by reacquiring a source spectrum, placing the cursor on the peak channels for the source, and verifying that each peak (as shown on the Certificate file) is within ± 0.3 keV. If this energy calibration check is satisfactory, save changes to the detector using the disk on the tool bar.

- **IF** the measured and calculated values do not align, **THEN** you need to examine the peaks selected and repeat.
- **IF** the curve is acceptable, **THEN** click the <OK> button to close the window.
- **IF** the curve is unacceptable, **THEN** repeat the energy calibration.

- **Energy calibration by nuclide list**:
  - Collect source spectra using guidance, as collected above.
  - Select <Calibrate>, from the Main Menu, and press <Energy Full> by Nuclide List. The “Calibrate by Nuclide List” window will open.
  - Select the appropriate radionuclides you want to use for energy calibrations (e.g., Cs-137 @ 662keV, Am-241 @ 59.5keV Co-60 @ 1332.5keV), then click <OK>. The “Energy Calibration – Full” window will open.

  Note: You must have a spectrum with at least three identified peaks and preferably at widely spaced energies.

  - Click the <Auto> button. The peak information will populate in the window.
  - **IF** any of the known peaks do not show up after <Auto> is pressed, highlight a radionuclide of interest, on the left side of the “Energy Calibration – Full” window, **THEN** place curser on that peak, in the Gamma Acquisition window, then click on the <Cursor> button. Continue until all peaks of interest are identified.
  - When all peaks are completed, click the <Accept> button.
  - Click on the <Show> button. The “Energy Calibration Curves” window will appear.
  - Evaluate the accuracy of the energy calibration by reacquiring a source spectrum, placing the cursor on the peak channels for the source, and verifying that each peak (as shown) is within ± 0.3 keV of the reference energy. If this energy calibration check is satisfactory, save changes to the detector using the disk on the tool bar.
  - **IF** the measured and calculated values do not align, **THEN** you need to examine the peaks selected and repeat.
  - **IF** the curve is acceptable, **THEN** click the <OK> button to close the window.

- **IF** the curve is unacceptable, **THEN** repeat the energy calibration.

Note: You may get a warning – "Deleting incomplete line: xxkeV (ch:00)" – where xx is the energy value for any radionuclide selected for which there was no peak identified. As long as there were at least three peaks identified across the energy range of interest this is not a problem, just click the <OK> button.

Note: The SME will verify and approve the energy calibration by signing the report package.

7.7.2 If no NIST traceable sources or certificate files are available, consult the SME or Health Physicist for guidance on performing a manual energy calibration.

7.8 Efficiency Calibration

7.8.1 If sample measurements are for screening (Nuclear Identification) purposes only, then an efficiency calibration may not be necessary. Consult the project SME or Health Physicist for guidance.

7.8.2 In order to quantify gamma spectrometry results, an efficiency calibration must be performed. An efficiency calibration can be made using a certificate file generated from a NIST traceable source if the geometry of the source is identical to the geometry of samples to be counted. Alternatively, an efficiency calibration can be performed using ISOCS modeling software. An efficiency calibration generated, by modeling, will be performed by the SME or by a gamma spectrometry operator under close guidance by the SME.

7.8.3 To load an **Efficiency** Calibration, by Certificate File or ISOCS, perform the following steps:

- Select <Calibrate> press <Efficiency>, and then press <By Certificate File>. The "Open Certificate File" window will open.
- Select the appropriate certificate file, and then click <Open>. The "Efficiency Calibration – Full" window will open.
- Click the <Auto> button to perform the efficiency calibration. The peak data information will populate in the window.
- Evaluate the efficiency curve by choosing <Show>.

Note: Before clicking on the "Drop Pk" button, make sure the number, in the box next to the "Drop Pk" button, matches the Pk/index number on the "List Peaks" window.

- Click on the "List Pks…" button to see specifics (e.g. peak energy, calculated vs. measured efficiency, and deviations) for each peak. If there are problems with a peak (e.g. high % deviations), that peak can

be removed by highlighting the peak and clicking on the “Drop Pk” button on the “Efficiency Calibration Curves” window.

- Select the curve type (e.g., Dual, Empirical, Linear, or Interpolated). These selections only change the manner in which the measured data points are fitted to an empirical curve. They can be changed at a later time.
- If the curve is acceptable, click the <OK> button to close the window. **IF** the curve is unacceptable, **THEN** contact SME.

7.8.4 An additional way to load an **Efficiency** Calibration, by ISOCS, can be performed by the following steps:

Note: The ISOCS software was developed by Canberra to generate mathematically calculated efficiency values, for specified energies, without the need for radioactive standardized sources. For more information see the ISOCS User’s Manual (Canberra, 2002).

- Select <Calibrate> <Efficiency>, then <By ISOCS/LabSOCS>. The “Calibrate by ISOCS/LabSOCS: Select Input File” window will open.
- Select the appropriate Geometry File (*.ecc).
- **IF** an appropriate Geometry file does not exist, **THEN** contact the SME.

7.9 Analysis of Non-Destructive Assay Data

7.9.1 Verify Analysis Sequence

- Analysis of spectrum files collected with a gamma spectrometry system will require an efficiency calibration file (.CAL).
- All ISOCS source models will be created and/or reviewed by an SME, prior to their use, to ensure proper QC.
- In order to ensure data collected using the ISOCS system is valid, compliance with the QA requirements, established in Section 7.11, must be demonstrated and documented for each day’s use.
- Gamma spectra are analyzed using established analysis sequences. An analysis sequence is setup, by the SME, at the start of the project. The sequences, on the NDA computer, can be found by selecting <Analyze><Execute Sequence>.
- Analysis sequences are usually customized for particular projects, but typically will contain the following steps:
    - Peak Locate
    - Peak Analysis
    - Area Correction (i.e., background subtraction)
    - Efficiency Correction (Select proper efficiency to be used)

- Nuclide Identification (with Interference Correction)
- Detection Limits (MDA)
- Reporting (multiple reporting steps are required to print the results of each analysis step)

Note: Nuclide Identification is performed using a designated nuclide library. Libraries contain the radionuclide name, energy, and abundance information for gamma-emitting radionuclides of interest. Libraries can be customized, as required, based on project requirements. It is important to verify the nuclides listed, their energies, and the percent abundances of those energies prior to using a library file.

- Setup and testing, of the required analysis sequences, will be performed or reviewed by a qualified SME using the following steps:
  - Review the analysis sequence to verify the steps and parameters being used are appropriate for the project.
  - Ensure that the nuclide energy lines and relative abundance information, in the chosen library, are correct and adequate to meet project requirements.
  - Verify that the approved library file is being called in the analysis sequence. The radionuclide library file name used in the spectrum analysis will be recorded, in the notebook or appropriate project specific forms and/or documentation, and will be identified in the printed report.
  - Annotate the ISOCS model input file to state the particular source specifications, underlying assumptions, and design dimensions for each model. The primary assumptions and modeling parameters should also be written in the project notebook.
  - Verify if 'background subtract' should be a part of the spectra analysis. If yes, verify weekly that correct background file is used.

7.9.2 Advance Analysis of Non-Destructive Assay Data

For the SME – Some projects will require advance analysis of collected data. Evaluate project's needs with a Health Physicist and adjust Analysis Sequence to include some or all of the tools described below.

- Line Activity Correctness Evaluator (LACE) – Canberra's Line Activity Correctness Evaluator can be used to examine the activity of a given nuclide across a range of its gammas. LACE analysis is effective for nuclides with 3 or more peaks. The ratio, of each line's activity relative to a chosen line of high abundance, should all be equal to one. The

negative slope of the fitted line implies that used efficiency calibration is overestimated at low energies. Similarly, positive slope of the fitted curve implies underestimation at low energy (for example due to underestimation of the density in the ISOCS model, or due to presence of attenuation with a calibration source). If outliers exist, in the plot, then an indication of other problems could exist such as coincidence summing.

- MGAU and FRAM – It is industry practice to use isotopic codes, such as FRAM, MGA, or MGAU, to determine isotopic ratios for uranium- and plutonium-bearing materials. These codes use sophisticated deconvolution algorithms to separate peaks that are close in energy. Since gamma energies from two isotopes that make up an elemental compound are close together, regardless of the geometrical configuration or matrix, the attenuation is relatively the same. Since this is the case, adjusting ISOCS models to match the correct isotopic ratios produced by isotopic codes helps to remove bias, from the model, and also verify its accuracy.
- ISOCS Uncertainty Estimator (IUE) – In some situations, a detailed Total Propagated Uncertainty (TPU) estimate is required. The modeling tool, IUE, assumes finite model parameter values to determine the detector's efficiency and associated measurement uncertainty. This software can be used, to modify the model, to evaluate a range of values rather that a definite value. An error distribution is assumed for each range. The type of distribution and its confidence is dependent on each unique situation.
- Sensitivity Analysis – This tool evaluates various model parameters and looks at the fractional change in efficiency, at the energies used to determine detector efficiency. This information will show the impact of model parameters, on detector efficiency, and help the user to determine what model parameters the user should focus on the most.

7.10 Report the Data

7.10.1 Analysis reports are automatically generated when an automatic sequence file (.ASF) is run. Each 'Reporting' step inserted, into an ASF file, will generate a section of the full analysis report based on the "Analysis.TPL" template file. The output reports will have an .RPT file extension and be automatically placed in the C:\GENIE2K\REPFILES folder.

7.10.2 Results, from analysis steps, are saved for a particular spectrum if the data source is saved. Data output options include making a hardcopy (sending the report directly to a printer), sending it to a file (sending a report to Acrobat to create a PDF file), and copying the contents of the report window to the Clipboard, for pasting into a word processing or spreadsheet program, for processing or editing.

7.10.3 After data is collected and analyzed, it must be verified to determine its usability. Data verification activities ensure that the data have been collected according to a specified method; and, have been faithfully recorded and transmitted from initial scan acquisition to final report.

Note: Attachment A is required for In-Situ NDA measurements and required to be attached to the report. All questions on the Attachment are required to be answered.

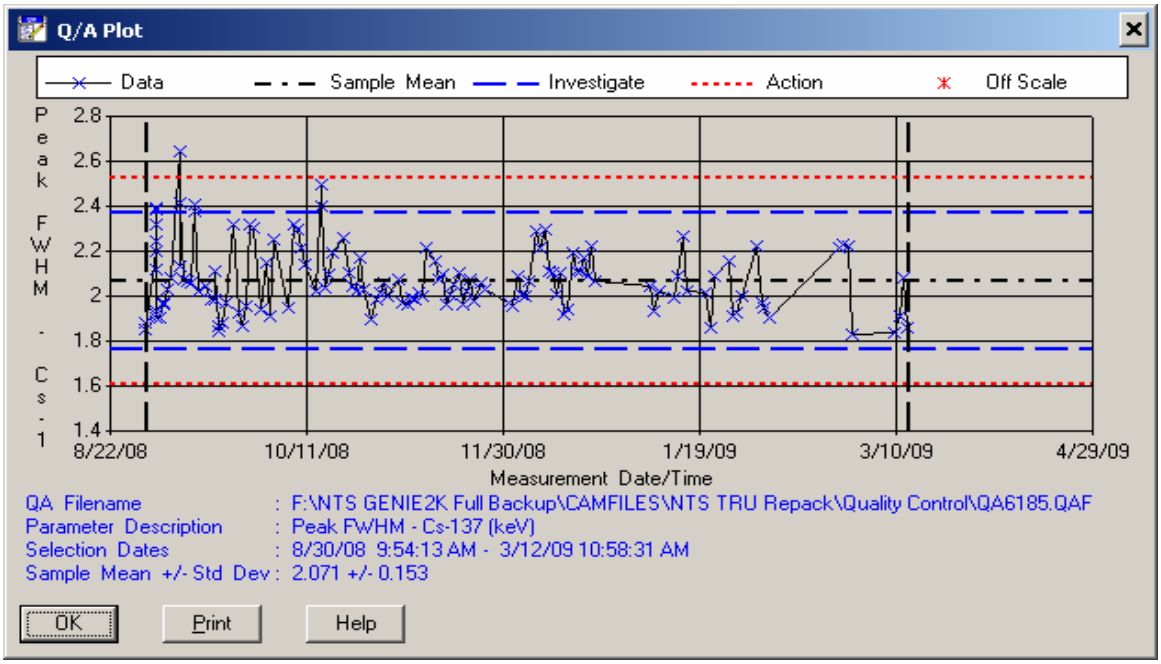
7.10.4 Data validation steps are performed to ensure data quality objectives have been met, QC criteria have been met, and evaluate if any data qualifiers are required to be reported, prior to release of the data.

7.11 Quality Assurance

7.11.1 Quality control charts for background measurements and response checks are used to ensure that the system is operating within specified limits. Measurements made day-to-day may vary. The energy versus channel (peak shift) and FWHM (resolution) are most likely to fluctuate, while efficiency is the least likely to vary. The background will not change greatly unless there is contamination inside the detector shielding or changes in the laboratory environment have occurred. Data generated by the QC process is stored in a database for plotting and archival purposes.

7.11.2 An example of a quality control chart is shown in Exhibit 1:

Exhibit 1 – Example Quality Control Chart



7.11.3 The long dotted lines (blue on screen) represent the ± 2-sigma statistical tolerance bands, while the smaller dotted lines (red on screen) represent the ± 3- sigma tolerance bands. For parameters evaluated against a boundary test (i.e., centroid energy), only one set of tolerance bands will be present.

7.11.4 Data showing precision and accuracy of detector performance is compiled and managed using Canberra's Quality Assurance Editor Software. Using this software, databases are established and data is transferred to them from QC counts. For details on establishing a QC database, see Chapter 2 of the QA Software User's Manual (Canberra, 2002).

7.11.5 A QC Calibration Check is performed with an operational check source. It should be measured, at least daily, or at the customers requested frequency. The check source(s) need not be NIST traceable. The check source(s) should be mounted in a reproducible fixture or jig and placed, at a reasonable distance from the detector end-cap, to produce adequate peak count rates above ambient background. An acceptable QC geometry is a 250 or 500 milliliter poly bottle with check sources taped under lid.

7.11.6 Typical radionuclides used for QC tracking and trending include:

Nuclide	Energy (keV)	QC Energy Range
Am-241	59.5	Low
Cd-109	88.03	Low
Eu-152	121.8	Low
	344.3	Mid
	778.9	Mid
	964.9	Mid
	1408	High
Cs-137	661.6	Mid
Co-60	1173.0	High
	1332.5	High

7.11.7 Collecting Initial QC source measurements

- The Operator will:
    - Prior to beginning collection of QC measurements, contact the SME to ensure that the system has already been properly calibrated and is ready to collect spectra.
    - Collect ten (or more) initial QC source measurements, for 5 to 10 minutes using the source jig, to setup baseline data for daily QC trending.
    - Save each measurement into the <Quality Control><Initial

Measurements> folder using the following convention: "Det#_InitialQC01_mmddyy.cnf", "Det#_InitialQC02_mmddyy.cnf", through "Det#_InitialQC10_mmddyy.cnf".

- Enter the source assay date in the sample date field found in the sample info menu (Edit/sample info). This step will decay-correct shorter lived nuclides (Cd-109, etc.) to a common date (i.e., source assay date or project start date if NIST traceable sources aren't used).
- Analyze source measurements using the applicable QC Analysis Sequence and then transfer into the QA Editor (using the appropriate project .QAF file) to establish baseline trend data.

- The SME will:
  - Verify that the parameters, in the project QAF file, are correct and that all boundary and statistical tests are set up correctly.
  - Verify the data entry, into the QAF file, by reviewing the trend plots or data reports.

7.11.8 Collecting Daily QC source measurements

- A Daily QC Calibration Check is performed, with an operational check source, at the start of each field measurement shift. The Operator will:
  - Place the check source at a reproducible position relative to the detector end cap. A typical arrangement, for a laboratory QC jig, is an empty Marinelli beaker with the sources attached and/or positioned with its interior in a constant geometry.
  - Perform QC source measurement using the same source and count time as those used during initial QC measurements.
  - Enter the source assay date into the "Sample Date" field in the <Sample Information> dialogue box.
  - Save and re-open the QC file ("Det#_DailyQC_mmddyy").
  - Analyze the spectrum using the appropriate QA Analysis Sequence, then save and close file.
  - Start the QA Editor, and then open the project's ".QAF" file.
  - Transfer the current QC data, into the QAF file, by Selecting <Results>, <Transfer>. Choose current "Det#_DailyQC_mmddyy" file.

- Choose <Results><Report Last Measurement> and check mark "Screen". If "page one" is check marked, then uncheck "page one" and check mark "new file". If desired, the file may be printed, to an Adobe PDF file, to save paper.
- Review the QC report on screen. **IF** none of the parameters show "**IN**" or "**AC**" under the deviation/flags area, **THEN** check the QC charts and verify that all parameters are within control. If so, then the daily QC is complete. Print the daily report then select <File>, <Save> and exit the QA Editor.

Note: "**IN**" signifies a result outside of ± 2-sigma (investigate) and "**AC**" signifies a result outside of ± 3-sigma (action) control parameters. If Investigate or Action flags occur, in a daily QC report, then contact SME or Health Physicist immediately. Measurements taken before the QC issue is resolved may be void.

- If one or more of the analysis results, under the deviation/flags section, is outside of the normal operating tolerance of the system, then consult the SME for additional guidance. Results of "IN" should be watched closely to determine if a trend for that detector parameter exists.
- If one or more of the analysis results, under the deviation/flags section, show "AC", then perform a 'Recount' measurement and save that measurement as, "Det#_DailyQC_mmddyyR." The Sample Info Box should have the word "Recount" entered after the Sample ID.
- Transfer and review the Recount results, in the QA Editor.
- If the same parameter shows "AC," in the re-count results, then contact the SME for guidance. Otherwise, accept the QC results.
- The QAF file should only contain duplicate entries for those parameters which failed (AC). Therefore, the parameters, from the recount that were not needed, must be deleted from the QAF file. Delete the recount data for any QC results that PASSED the first count using <Results>, <Edit Values>. The QC results that initially failed should NOT be deleted. When this is completed perform the recount again and attach the printed recount report to the original and file the results.

7.11.9 The specific QC parameters evaluated and the acceptable ranges of results are summarized in Exhibit 2:

Exhibit 2 – Quality Control Parameter Action Levels

Centroid channel (low-energy)	Within ± 1 keV Energy Boundary
Centroid channel (mid-energy)	Within ± 1 keV Energy Boundary
Centroid channel (high energy)	Within ± 1 keV Energy Boundary
FWHM (low-energy)	Investigate ±2 Sigma, Action ±3 Sigma
FWHM (mid-energy)	Investigate ±2 Sigma, Action ±3 Sigma
FWHM (high energy)	Investigate ±2 Sigma, Action ±3 Sigma
Activity (low-energy)	Investigate ±2 Sigma, Action ±3 Sigma
Activity (mid-energy)	Investigate ±2 Sigma, Action ±3 Sigma
Activity (high energy)	Investigate ±2 Sigma, Action ±3 Sigma

Note: Examples of low, mid, and high energy nuclides used for QC purposes are provided in Step 7.11.6.

Note: The mean and standard deviation values for these QC parameters are established by performing a set of 10 initial counts. Subsequent count results are then compared to the established "investigation level" range of [mean ± 2 standard deviations] and "action level" range of [mean ± 3 standard deviations]. The mean and standard deviation is updated after each transfer to the QAF file.

7.12 QC Trending and Reporting

7.12.1 QC results must be generated and reviewed daily. At least weekly (at the end of each work week), QC Trend Plots should be printed, from the QA Editor, and filed for review in a readily accessible folder. These printouts are intended to provide a record of stable system performance, or alert the user to possible system problems.

7.12.2 Reporting of daily and weekly QC detector data

- The Operator will:
  - Print the Daily QC data results each day (either to paper or to a PDF file). It is recommended that the results of the daily report be pasted into Microsoft Word, for printing, rather than using the print command in the QA Editor. This method creates an electronic copy of the report for quick printing, if required.
  - Document the QC results in the field notebook or appropriate project specific forms and/or documentation.
  - Generate parameter trend plots by selecting <Results>, <Show Chart>.
  - It is recommended that <Connect Data Points> be checked to help view the trend information.

- Select each of the trend parameters and select <Print> under each resulting graph.
- Print trend plots, at the end of each work week, and post or file, in a readily accessible area or folder, for review.

- The SME will:
  - Print the Daily QC data results each day (either to paper or to a PDF file). It is recommended that the results of the daily report be pasted into Microsoft Word, for printing, rather than using the print command in the QA Editor. This method creates an electronic copy of the report for quick printing, if required.
  - Document the QC results in the field notebook or appropriate project specific forms and/or documentation.
  - Generate parameter trend plots by selecting <Results>, <Show Chart>.
  - It is recommended that <Connect Data Points> be checked to help view the trend information.
  - Select each of the trend parameters and select <Print> under each resulting graph.
  - Print trend plots, at the end of each work week, and post or file, in a readily accessible area or folder, for review.

7.13 Daily Operations

7.13.1 Peak shifting, due to thermal changes in the electronics or environment, is common. High and low energy peaks seen in routine background spectra will be used to track energy drift, of the HPGe system, throughout the day. Natural product peaks such as ^{40}K at 1460.8 keV, or high-energy check source peaks, i.e., ^{60}Co at 1332.5 keV, can be used for this purpose.

Note: Higher energy photon peaks are used to test for spectral shifting since the conversion gain of InSpector MCAs is not linear with energy. For example, a small gain adjustment, at 60 keV, will result in a large adjustment at 1460 keV. Therefore, keeping a close eye on the high-energy photon peaks will ensure a more stable energy spectrum.

7.13.2 An overview of normal daily NDA operations

- The Operator will:
  - Perform Daily QC count, as outlined in Section 7.11.8, and prepare/sign report.
  - Perform project NDA counts, as required.

- At the end of the shift, return detector and platform to daily QC location and secure all equipment.
- Once a week (recommended either on the first or on the last day of the work week) start an overnight background count (minimum of 12-18 hours) and start the count before leaving the site for the day.

- The SME will:
  - Review and sign Daily QC Report.
  - Review and sign all data packages prepared for the day.

7.14 System Shutdown

If the detector needs to be removed from the counting platform, or all NDA work has been completed for the project, use the following steps to perform a system shutdown:

7.14.1 Select <MCA>, <Adjust>.

7.14.2 Select the HVPS tab.

7.14.3 Change Status to <OFF> and wait until the "WAIT" signal, at the top left of the dialogue box, disappears. When it does, press <EXIT>.

Note: Turning off the HV takes approximately 45 seconds.

7.14.4 Verify that the green HV light, on the front panel of the MCA, is off.

7.14.5 Save the current detector settings by pressing the disk icon, in the top toolbar, and then close the detector data source.

7.14.6 Stop the USB communication between the computer and the InSpector by selecting the 'Safely Remove Hardware' icon (green arrow) in the toolbar, at the bottom right of the Windows screen, and select "Safely Remove Inspector 2000." You will be prompted when it is safe to remove the USB cable from the computer.

7.14.7 Turn off the MCA power.

7.15 Gamma System Upkeep and Maintenance

7.15.1 Detector maintenance

- Any maintenance performed on the ISOCS will be recorded in the field notebook or appropriate project specific forms and/or documentation.
- Routine maintenance on the HPGe detector consists of adding LN_2 to the cryostat.
- Routine maintenance is not required on the Canberra MCA.
- Shield and collimator components, of the ISOCS, should be handled carefully so as not to damage the machined mating surfaces. Following

use in the field, surfaces should be wiped free of any dirt, dust, or foreign matter. When not mounted on the ISOCS cart, components should be stored or transported in containers with cushioned lining.

- Non-routine maintenance on the electronics should be performed by the SME or designated alternate. The Canberra Industries customer service department should be consulted when problems arise which cannot be handled by site personnel.

7.16 LN_2 Refills

7.16.1 The LN_2 Dewar will be refilled on the following schedule:

- 30-liter laboratory stationary Dewar: Once per 2-3 weeks. Preferably, Dewar should be kept no lower than 1/3 of the capacity to maintain thermal integrity to the detector.
- Big MAC portable Dewars: Once every 3 or 4 days, depending upon LN_2 loss rates (outdoor temperature, physical handling, etc.).

7.16.2 A replacement LN_2 canister should be ordered when cylinder pressure falls below 10 psi or the level indicator falls below one-half (½).

Note: The level indicators, on rented LN_2 cylinders, are notoriously unreliable. It is far better to use internal cylinder pressure, as a gauge, to assess when the tank is nearly empty.

7.17 Use of Transfer Dewars

7.17.1 Transfer Dewars are used to fill the detector Dewar when the vendor supplied canister cannot be placed in close proximity to the lab.

7.17.2 Take the same precautions and safety measures when using a transfer Dewar as when doing direct LN_2 transfers between canister and detector Dewar.

7.17.3 A transfer Dewar looks just like a standard Dewar, except that it is equipped with a closure bung and shutoff valve at the top. It is filled by attaching the flexible hose from the canister to the inlet and opening the shutoff valve to allow the Dewar to fill.

7.17.4 Transfer Dewars rely upon internal pressure to force the liquid nitrogen out. Therefore, after the transfer Dewar has been filled, you may need to allow several hours for the pressure to build-up before successful transfer of the LN_2 to the detector Dewar can be sustained. Letting the transfer Dewar sit overnight is recommended. Before transfers are attempted, a minimum of 2-3 psi is recommended.

7.18 Gamma Acquisition Software Operations

The following steps are presented for assistance in operating the Gamma and Acquisition (GAA) Program (subset program of Canberra Genie-2K Suite).

7.18.1 Launching GAA – The GAA can be opened from the Windows desktop by double-clicking on the GAA Icon or by choosing Start, then Programs, then Genie 2000, then GAA.

7.18.2 Before opening the detector, the Inspector must first be switched on. The switch is located on the back left side of the Inspector.

7.18.3 Opening the Detector

Choose File (located on the menu bar), then Open. Open file type Detector from the "data source" choices and select the specific detector (e.g. DET01).

7.18.4 Applying High Voltage to the Detector

- Ensure that the detector has been properly cooled with liquid nitrogen for no fewer than six hours before performing this step.
- Choose MCA (located on the menu bar), then Adjust. A box will appear in the lower portion of the screen. Select the HVPS tab. Select the On button, after the Wait signal has disappeared, exit from the Adjust box by single clicking on the Exit button.

7.18.5 Selecting the Appropriate Count Time

- The count times used will be provided by the SME or Health Physicist. They will be chosen to ensure that project MDAs are met.
- To set the appropriate count time, select the edit icon located on the shortcut menu bar or select MCA, then Acquire Setup from the menu bar. Enter the appropriate time, into the Live Time box, where prompted. Count times must be entered as live time NOT real time, so the instrument dead time correction functions properly.

7.18.6 Starting/Stopping Data Acquisition.

To begin data acquisition, press the **Start** key under **Acquire**. The **Start** button will no longer be bold face when the acquisition begins. Acquisition can be stopped, at any time, by pressing the **Stop** button located immediately to the right of the start button. If acquisition is stopped and a preset time is entered (see Section 7.21.2), press the **Start** button to resume acquisition. Acquisition will then continue until the preset time is reached.

7.18.7 Clearing Spectrum Data

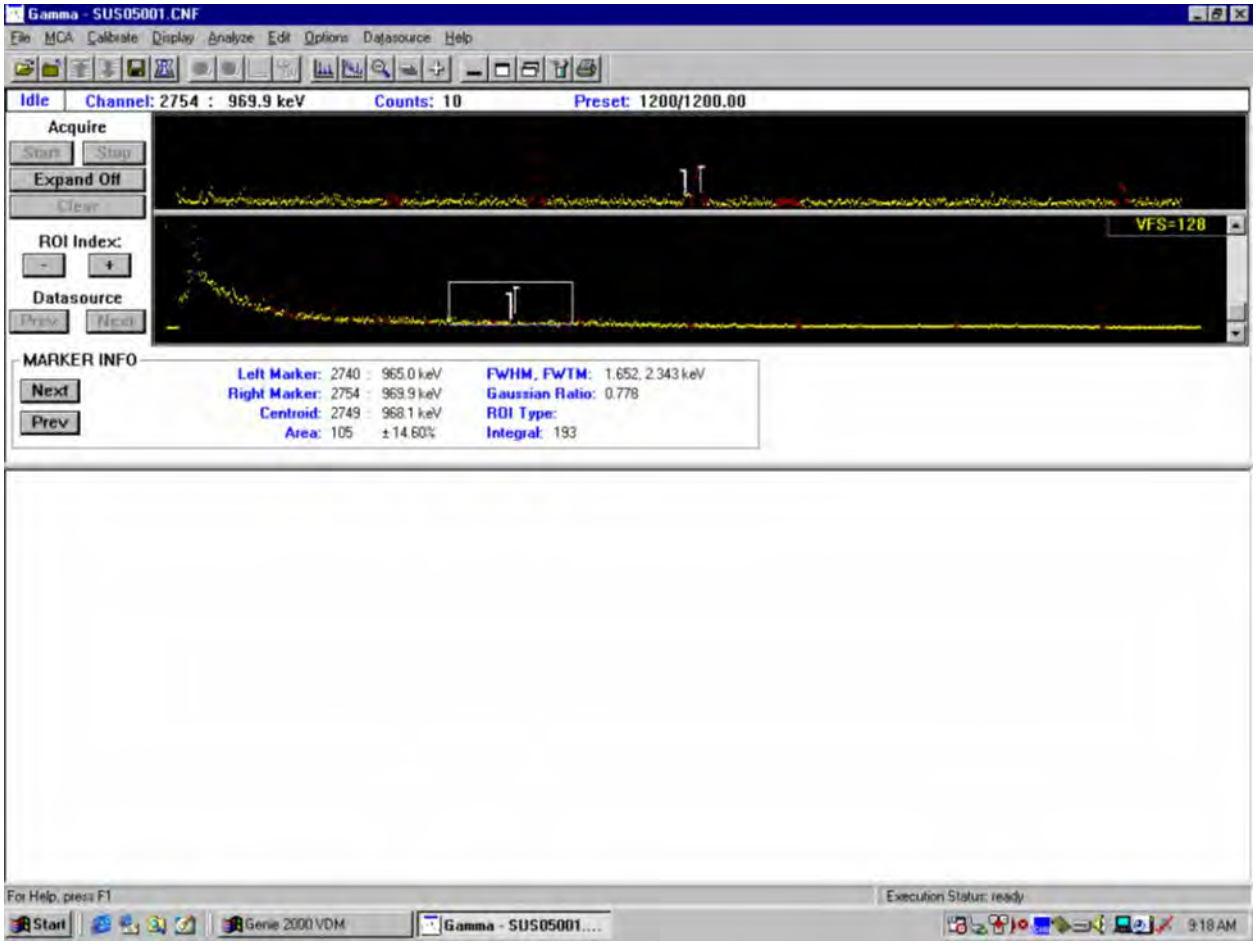
To erase the spectrum data, press the **Clear** key under the **Start** and **Stop** buttons under **Acquire**. The **Clear** key works during active data acquisition and when counting has been paused.

Note: Remember to save current detector settings by choosing the save disk icon on the tool bar before clearing data. Otherwise, data will be lost.

7.18.8 Information from the Spectrum Display

- In the Spectrum Display, the left and right arrow keys will move the spectrum cursor. The information bar, above the Spectrum Display, will indicate the energy level (keV) and channel number corresponding to the location of the cursor, as well as the total number of Counts at that energy level and the Elapsed/Preset time.
- The Elapsed/Preset times are shown in an incremental fashion. In Exhibit 3, the acquisition had been completed, therefore, the elapsed time was 1200 seconds and the preset time was 1200 seconds. If the instrument had only reached 200 seconds of the preset 1200 seconds, then the display would show 1200/200.
- The spectrum Vertical Full Scale (VFS) display scale can be expanded or contracted by pressing the up and down arrow, respectively. The spectrum display vertical scale will automatically adjust when counts in any channel exceed the current vertical scale. The initial vertical scale is 16.

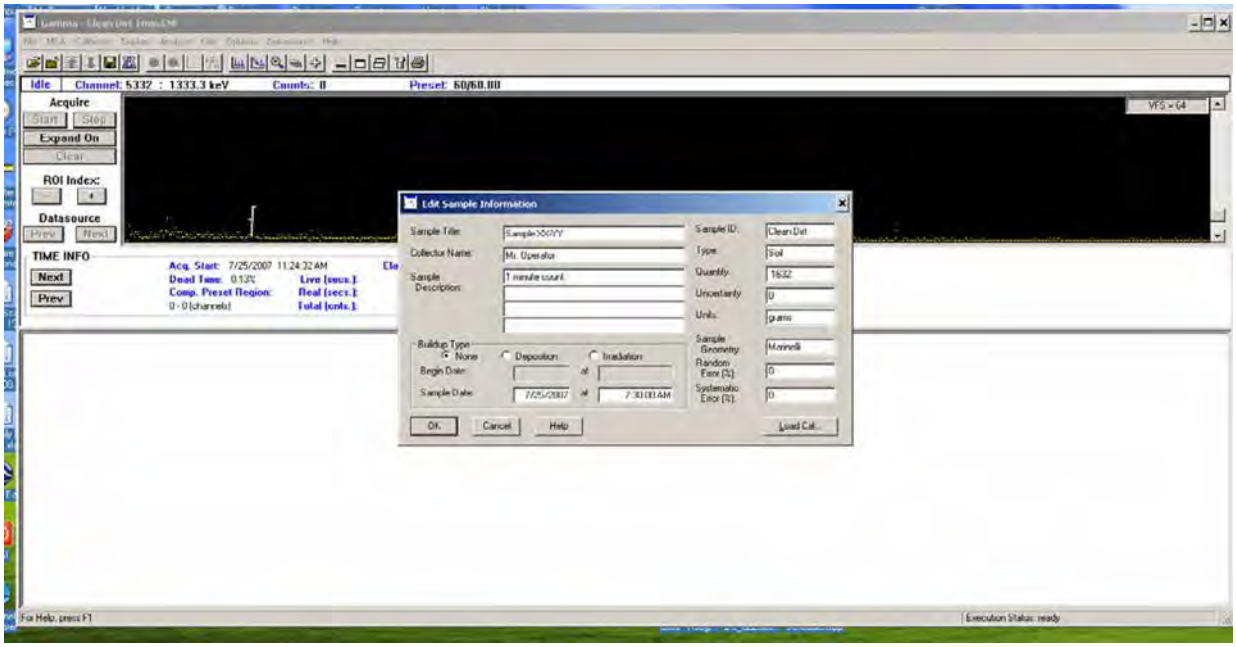
Exhibit 3: GAA Screen with Marker Info Displayed



7.18.9 Identifying Sample Spectra

- Descriptive information is entered to uniquely identify each acquired spectrum. This can be done while data acquisition is in progress, or after acquisition has stopped and prior to saving the spectra. Use the info box shortcut or select Edit in the GAA window menu bar, then select Sample info from the Edit menu. This will display the Edit Sample Information dialog box, which includes descriptive fields for: Sample Title Collector Name, Sample Description, Sample ID, Type, Units, and Sample Geometry.
- Editable fields are also provided for Quantity, Uncertainty, Random Error, and Systematic Error. Select the None button in the Buildup Type section, and leave the Sample Date fields blank unless informed otherwise by the Senior Health Physicist.
- Make sure to enter the following information, for every sample analysis, in the fields of the Edit Sample Information dialog box (see Exhibit 4):
    - The Sample Title should be entered showing the Sample ID and this ID should be exactly the same as the file name.
    - Collector Name
    - Sample Description should present any notes regarding this sample.
    - The detector number, for example “DET 6228DIG/DET 6185ANA”, should be entered into the box named ‘Type’.
    - The Quantity box should present the sample mass minus the container tare mass in grams.
    - The Units box should have “gram” typed in it.
    - Now select the OK button to save the information and exit this dialog box.

Exhibit 4 - View of Edit Sample Information Dialog Box.



7.18.10 Saving a Spectral Data File

- After spectral acquisition has stopped, the spectral data and related information can be saved in a file. This step is required before analyses of the acquired spectrum can be performed.
- Select File in the GAA window menu bar, and then select Save As. This will display the Save As dialog box. Enter the desired name of the file in the name field. The extension ".CNF" will be added to the name by the GAA software.
- Enter an appropriate supplemental text string (up to 32 characters) in the Description field. Enter text that will be helpful in selecting this file when attempting to identify it at some later time.
- Select the OK button to save the file and exit the Save As dialog box. The default directory used to store these files is GENIE2K\CAMFILES.
- To collect additional spectra, clear existing spectral data from the graphics region of the GAA window.

7.18.11 Analyzing a Spectral Data File

- After opening a CAM file data source and loading the appropriate ISOCS efficiency calibration parameters, spectral data analysis can be performed. The Analyze options in the GAA window menu bar can be used to perform these analyses.

- Choose Analyze in the GAA window menu bar to display the Analyze menu.
- Next, choose Execute Sequence and select the sequence specified by the Senior Health Physicist. Usually, only one analysis sequence will be used at each work site.

7.18.12 Exiting the GAA Application

- When all spectral data analyses have been completed, select File in the GAA window menu bar. Select Close from the File menu. If a data source with unsaved changes was still open in the GAA window, a message screen will be displayed asking whether the latest changes should be saved. Respond appropriately to any such message.
- Before completely exiting from GAA, turn off the high voltage to the detector by reversing the steps for applying high voltage in Section 7.5.2.

8.0 REFERENCES

- Canberra. 2000. Model 1300 InSpector 2000 Hardware Manual. Canberra Industries, Meriden, CT.
- Canberra. 2001. Germanium Detector User's Manual. Canberra Manual 9231358A, 10/98. Canberra Industries, Meriden, CT. Canberra. 2002a. Genie 2000 Operations Manual. Canberra Industries, Meriden, CT.
- Canberra. 2002b. Model S573 ISOCS Calibration Software User's Manual. Canberra Industries, Meriden, CT.
- Canberra. Verification of Gamma Spectroscopy Programs: N42.14 and Beyond. Canberra Industries, Meriden, CT.

9.0 REQUIRED RECORDS

- Daily QC Reports
- Weekly QC Trend Graph Plots
- All logbooks

10.0 ATTACHMENTS

- Attachment A – In-Situ NDA Worksheet and Checklist
- Attachment B – Diagram of ISOCS Shield Assemblies and Standard Rolling Cart

Attachment A
In-Situ NDA Worksheet and Checklist

In-Situ NDA Worksheet and Checklist

Measurement Scenario Information and Model Description

Measurement Difficulties and Uncertainty Factors Encountered

(Please check all that apply)

Suspected Poorly Defined Matrix		Suspected Self-attenuation	
Suspected Poorly Defined Geometry		High Background Environment	
Was sample rotated?		Suspected High Density Matrix	
List Other Factors -			

Complete the Following

Energy Calibration Date			Verify Sample Edit Window Information Below	
Efficiency Calibration Date			Sample Quantity is Correct	☐ Yes ☐ No
Daily QC Report Attached	☐ Yes ☐ No		Sample Date is Correct	☐ Yes ☐ No
Analysis Library File Used	.NLB		Sample Unit is Correct	☐ Yes ☐ No
Analysis Sequence File Used	.ASF		Collimation Type	30 / 90 / 180

Measurement Activity Values

Detector #	pCi/gram	UNCpCi/gram

LACE Reports Attached - ☐ Yes ☐ No (If no please explain or describe LACE results)

MGA/MGAU Analysis Performed - ☐ Yes ☐ No
(If yes please explain or describe model differences)

MGAU Value	Model Value	% Difference

Additional Uncertainties Propagated into Measurement TPU - ☐ Yes ☐ No
(If no skip this section)

Model Parameter	Low	High	Model Value	Error Distribution

Sensitivity Analysis Results - ☐ Yes ☐ No (If no skip this section)

Model Parameter	Impact on Model Results

Additional Comments

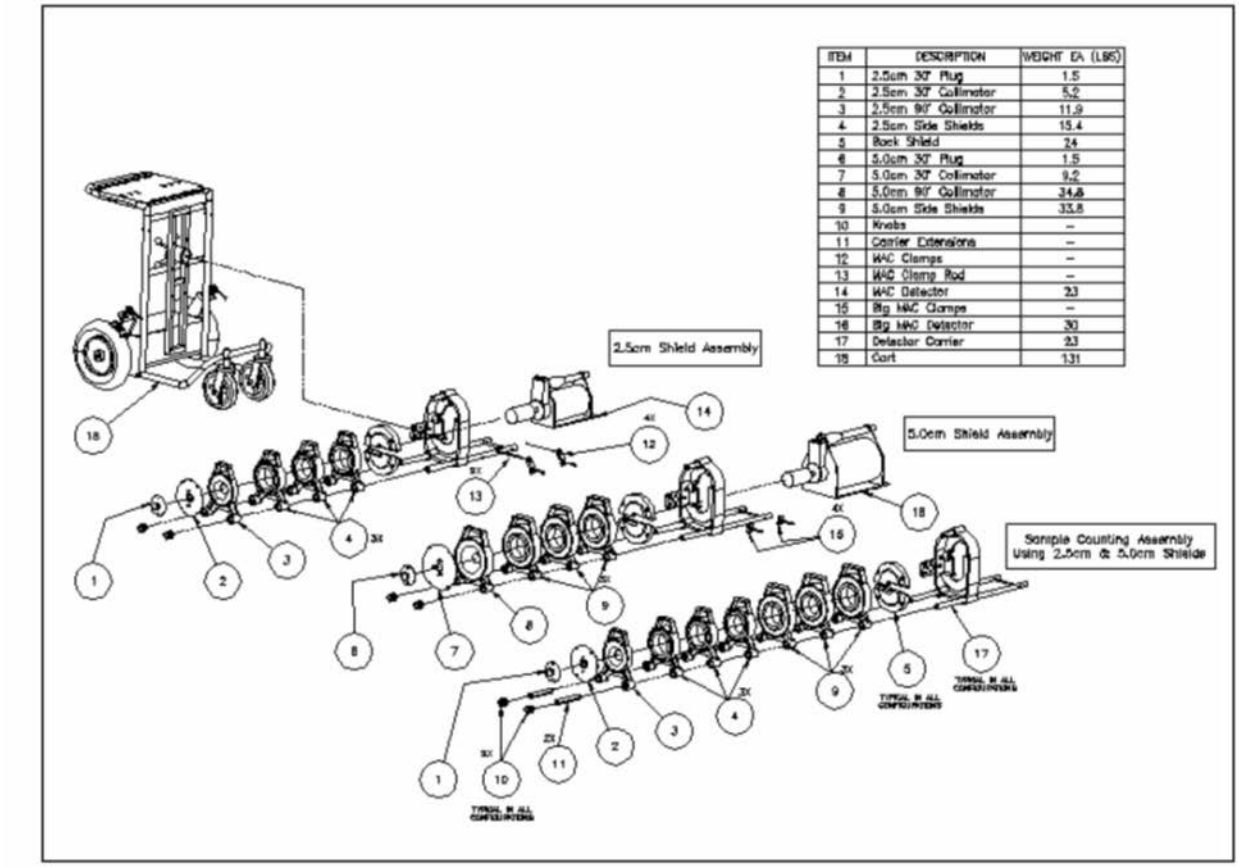
Gamma Spec Operator _____ Date_____

SME _____ Date_____

Lab Director or Health Physicist _____ Date_____

The data and associated reports are attached.

Attachment B
Diagram of ISOCS Shield Assemblies and Standard Rolling Cart


ITEM | DESCRIPTION | WEIGHT EA (LBS)
1 | 2.5cm 30° Plug | 1.5
2 | 2.5cm 30° Collimator | 5.2
3 | 2.5cm 90° Collimator | 11.9
4 | 2.5cm Side Shields | 15.4
5 | Back Shield | 24
6 | 5.0cm 30° Plug | 1.5
7 | 5.0cm 30° Collimator | 9.2
8 | 5.0cm 90° Collimator | 34.6
9 | 5.0cm Side Shields | 33.8
10 | Knobs | --
11 | Carrier Extensions | --
12 | MAC Clamps | --
13 | MAC Clamp Rod | --
14 | MAC Detector | 23
15 | Big MAC Clamps | --
16 | Big MAC Detector | 30
17 | Detector Carrier | 23
18 | Cart | 131
2.5cm Shield Assembly
5.0cm Shield Assembly
Sample Counting Assembly Using 2.5cm & 5.0cm Shields

CABRERA SERVICES
RADIOLOGICAL • ENGINEERING • REMEDIATION

OPERATING PROCEDURE

FOR

SAMPLE MANAGEMENT – ONSITE LABORATORY

OP-468

Revision 1
January 2016

Prepared by:

	January 22, 2016
Gordon McElheny	Date
Project Chemist/Lab Director	

Approved by:

	January 22, 2016
Sean Liddy, CSP	Date
OH&S/Quality Assurance Manager	

1.0 PURPOSE

The purpose of this Operating Procedure (OP) is to provide Cabrera Services Inc. (Cabrera) personnel with the requirements for managing environmental samples at Cabrera environmental monitoring laboratories. Adherence to this procedure will ensure samples are managed in accordance with State, Federal, and Licensee requirements.

2.0 APPLICABILITY

This procedure applies to all Cabrera employees and operations. Personnel shall utilize this procedure for all environmental field samples brought into an onsite laboratory unless specified otherwise through the project specific Field Sampling Plan (FSP), or Quality Assurance Project Plan (QAPP). Personnel must assure that the specifications of this OP agree with the specifications listed in the Project Work Plans.

3.0 DEFINITIONS

3.1 Project Plans - For the purposes of this procedure, a generic term describing the project implementing plans that contain the information associated with the requirements for mandated sampling. These include, but are not necessarily limited to:

3.1.1 Project Work Plan (PWP) - The over-arching project plan used to manage both project execution and project controls. A primary use is to document planning assumptions and decisions including quality assurance and quality control (QA/QC) measures regarding data gathering and deliverables.

3.1.2 Field Sampling Plan (FSP) - Provides specific directions for conducting each separate field sampling activity and presents the rationale and design, for the work, as well as the field procedures for each specific activity required. Field operations and documentation are also described and may include discussions on field logbooks, photographic records, sample documentation, field analytical records, and procedures for their management and retention.

3.1.3 Quality Assurance Project Plan (QAPP) - Focuses primarily on the analytical methods and QA/QC procedures that are used to analyze and manage environmental samples and their resulting data. The QAPP also presents the project organization, objectives, procedures, functional activities, and specific QA/QC activities associated with sampling, data management and record retention.

3.1.4 Site Safety and Health Plan (SSHP) – Provides evacuation routes for the site and immediate area; site-specific safety information; a

Chemical Hygiene Plan for laboratory operations which will include Safety Data Sheet (SDS) for any relevant chemicals of concern; and names and telephone numbers of common emergency contact personnel for the worksite. In addition, the SSHP may also contain sampling activities required to monitor worksite safety and health.

3.1.5 Quality Assurance (QA) - All procedures, practices, records, and other documentation required to provide confirmation that project activities are completed in a manner compliant with regulations, specifications, and/or contract requirements.

3.1.6 Quality Control (QC) - For the purposes of this procedure, actions taken to control the variable attributes of the sampling and analytical processes to meet the data quality objectives described in the project plans.

3.2 Sample Tracking Log - A quality control form that lists all of the samples collected, list the analyses to be performed, and tracks their destination.

3.3 Chain of Custody - The Chain of Custody lists and describes a shipment of samples that leave the custody of the sampler and are transferred to the custody of the laboratory. For additional information, please refer to OP-008, Chain of Custody.

4.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

4.1 Precautions

Environmental samples usually consist of environmental media (soil, water, air) that may have been impacted by source area materials, but not to an extent that they would contain any free product or hazardous concentrations of contaminants. Examples of these types of samples might include soils with no visible staining or strong odors, surface and groundwater samples with no floating product, and air samples collected on sorbent tubes or filters.

Many environmental field samples are preserved using concentrated acids. These preservatives are typically placed in otherwise empty containers by the laboratory. Personnel must wear appropriate PPE and exercise appropriate care when handling sample containers. Preservative may leak from containers during shipment, or may be released into packaging from broken containers. Preservative can be splashed into the air when containers are opened.

All samples should be stored/maintained in a location with adequate ventilation. Samples having significant volatile organic compound (VOC) or semi-volatile organic compound (SVOC) concentrations can slowly release vapors into a confined space over time such that local concentrations may exceed action limits.

4.2 Limitations

Onsite storage may not be appropriate for samples having short holding times. The Field Site Manager (FSM) must take into account the time required for sample shipment, receiving, and sample extraction/preparation in order to determine appropriate onsite holding times.

4.3 Requirements

Sample names are unique identifiers. Sample codes must be assigned such that they discriminate a sample from any other samples. Refer to OP-362, Sample Management and Shipping, for the requirements associated with proper sample numbering and tracking. 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 samples are to be handled by as few people as possible and the chain of custody form must document the change of possession by the appropriate dated signatures.

Field Personnel shall discuss deviations to the Project Work Plans with the Project Manager. Any deviations, plus conversations with the PM, shall be documented in the project field notebook.

5.0 EQUIPMENT

- Either pre-printed or on-site printed sample labels
- Custody seals
- Sample tracking log
- Field notebook
- Secured staging area with appropriate ambient temperatures and access controls

6.0 RESPONSIBILITIES

6.1 Project Manager (PM) - The PM is responsible for implementing and ensuring compliance with the contents of the project plans. They also must ensure that project personnel have been trained and are qualified to implement this procedure.

6.2 Laboratory Manager - The Laboratory Manager is responsible for the overall management of environmental samples brought into the onsite laboratory for analysis, to include; the logging, tracking, storage, archiving and disposal of the sample.

6.3 Project Personnel - All Cabrera personnel are responsible for reading, understanding, and complying with the provisions of this procedure prior to engaging in sampling activities. In addition, site workers should discuss any deviations from the prescribed sampling protocols with the PM or FSM, and document that conversation in the project field notebook.

7.0 PROCEDURE

This procedure provides steps to ensure that environmental samples are properly managed at all times; from the time they are received by laboratory personnel until they are disposed of or relinquished. This procedure will play an important role in the quality control of samples; ensuring that no sample is misplaced, all samples are counted, analyzed, stored, and disposed of safely.

7.1 Sample Labeling & Numbering

Sample labeling and numbering shall be performed in accordance with Sections 7.1 and 7.2 of OP-362, Sample Management and Shipping. The QAPP should specify whether the lab's Chain of Custody should be used or whether a Cabrera chain of custody should be used. Information on how to complete a Chain of Custody may be found in Cabrera OP-008, Chain of Custody (CoC).

7.2 Sample Delivery to On-site Laboratory

Field personnel are responsible for the samples and CoC until they are relinquished to a member of the laboratory.

Upon receipt of the samples from the field personnel, the laboratory personnel are responsible for verifying that the information on the field CoC matches the label information on the samples. If there is a discrepancy, the laboratory personnel shall note it in their log, and contact the field person responsible for the entry, or the Project Manager or designee to obtain the correct information and note it accordingly on the CoC and in their log.

All samples must be logged within 24 hours of receipt. All samples received shall be documented by either a written record (i.e. a logbook) or electronically on a database that is backed up daily. The Laboratory Log Record shall be updated at the time samples are received.

7.3 Sample Tracking

The tracking of samples shall be completed by making accurate record of the samples collected in a field log book, a sample tracking log, and through the use of a Chain of Custody. The QAPP should specify whether the lab's Chain of Custody should be used or whether a Cabrera chain of custody should be used. Information on how to complete a Chain of Custody may be found in Cabrera OP-008, Chain of Custody.

Sample tracking provides assurance that appropriate analyses are requested, and that the sample can be entered into the site data set. Cabrera's Sample Tracking Log is an electronic tool (Excel File) used to capture information about the sample, including associated Quality Control samples, and includes options for generating sample labels and printing chain of custodies. A copy of this Tracking Log may be found with OP-362.

7.4 On-site Sample Storage, Archiving and Disposal

The typical uses for onsite sample storage include: holding samples when they cannot be shipped, holding sample splits pending decisions on additional analysis, holding samples following onsite analysis pending decisions on final sample disposition.

Samples must be maintained in the custody of the Laboratory, which will utilize the Sample Tracking Log, or similar means, to monitor the location of each sample. In order to maintain a chain-of-custody, the sample storage area must not be accessible by unauthorized personnel, either through the use of custody seals or locks.

The sample storage area must have the proper environmental controls to keep the samples within an acceptable temperature range and samples shall be stored in a way that prevents cross contamination.

Samples shall be stored for a period of six months, or longer if requested by the client. Samples that have exceeded the required holding times will be disposed of in accordance with State, Federal, and Licensee requirements.

8.0 REFERENCES

- Cabrera OP-008, Chain of Custody
- Cabrera OP-362, Sample Management and Shipping
- 40 CFR, Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants (2003)
- Standard Methods, 20th Edition, 1998, Method 1060c, Sample Storage and Preservation.
- DoD QSM, Department of Defense (DoD) , Department of Energy (DOE) Consolidated Quality Systems Manual for Environmental Laboratories, Version 5.0, July 2013.
- Ramsey, Charles and Suggs, Jennifer, Improving Laboratory Performance Through Scientific Subsampling Techniques, Environmental Testing and Analysis, March/April 2001.

- EM 200-1-3, “Engineering and Design – Requirements for the Preparation of Sampling and Analysis Plans, Appendix I – Shell for Analytical Chemistry Requirements,” USACE, February 2001.

9.0 REQUIRED RECORDS

- Chain-of-Custody forms
- Sample Tracking/Control Log
- All field notebooks and/or sample documentation

10.0 ATTACHMENTS

None.

APPENDIX D
DRUM HANDLING PROCEDURES

11. Handling Drums and Other Containers

Contents

Introduction

Accidents may occur during handling of drums and other hazardous waste containers. Hazards include detonations, fires, explosions, vapor generation, and physical injury resulting from moving heavy containers by hand and working around stacked drums, heavy equipment, and deteriorated drums. While these hazards are always present, proper work practices-such as minimizing handling and using equipment and procedures that isolate workers from hazardous substances-can minimize the risks to site personnel.

This chapter defines practices and procedures for safe handling of drums and other hazardous waste containers. It is intended to aid the Project Team Leader in setting up a waste container handling program. In addition to reading this chapter, the Project Team Leader should also be aware of all pertinent regulations. OSHA regulations (29 CFR Parts 1910 and 1926) include general requirements and standards for storing, containing, and handling chemicals and containers, and for maintaining equipment used for handling materials. EPA regulations (40 CFR Part 265) stipulate requirements for types of containers, maintenance of containers and containment structures, and design and maintenance of storage areas. DOT regulations (49 CFR Parts 171 through 178) also stipulate requirements for containers and procedures for shipment of hazardous wastes.

Containers are handled during characterization and removal of their contents and during other operations. A flow chart showing one set of possible procedures for drum handling is given in Figure 11-1. Guidance

for safely performing the procedures shown in Figure 11-1 is provided in the following sections of this chapter. The final section, *Special Case Problems*, describes the handling of tanks, vaults, vacuum trucks, elevated tanks, and compressed gas cylinders.

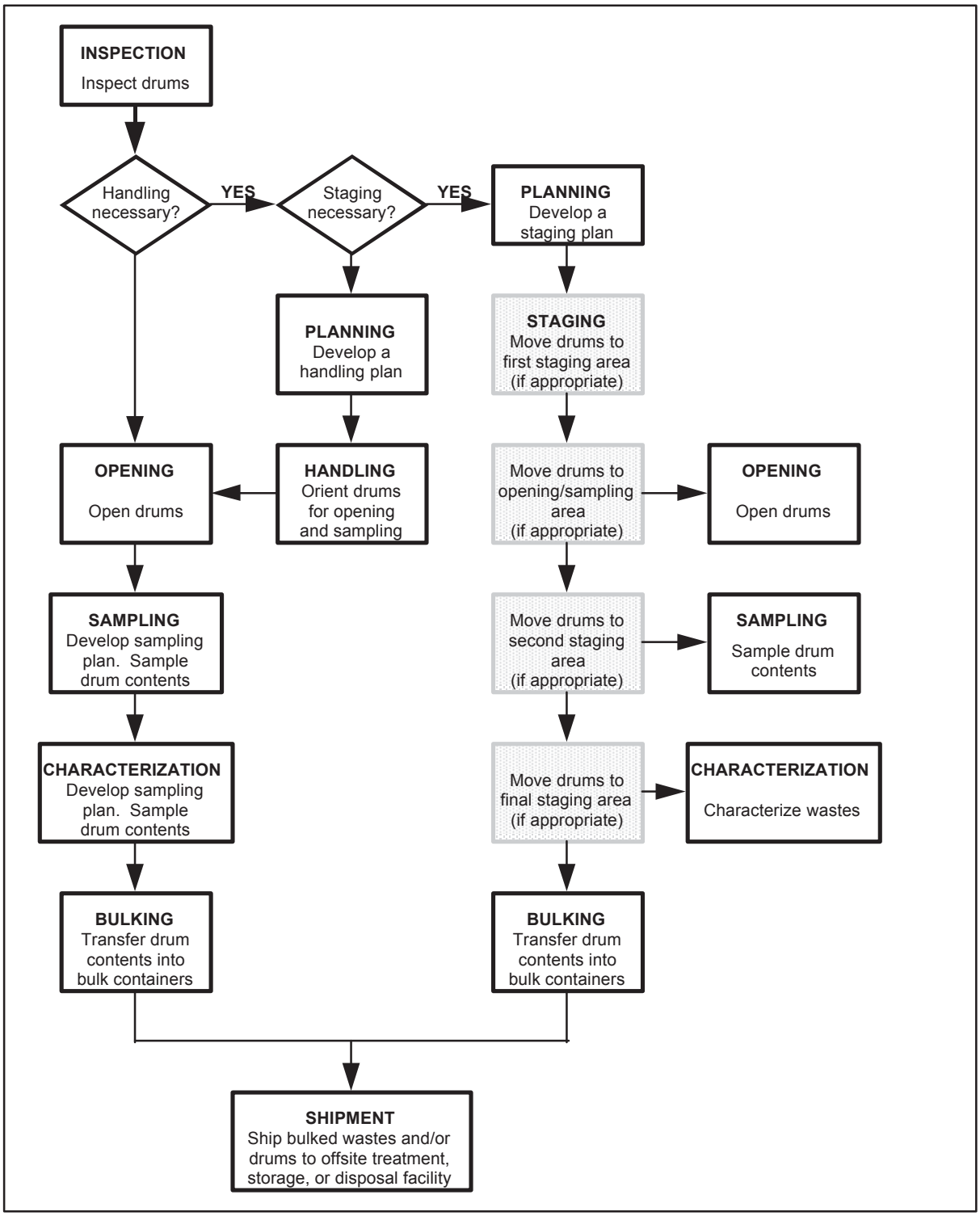


Figure 11-1. Flow Chart for Drum Handling. (Dashed boxes indicate optional steps. Number of staging areas necessary is site specific.)

Inspection

The appropriate procedures for handling drums depend on the drum contents. Thus, prior to any handling, drums should be visually inspected to gain as much information as possible about their contents. The inspection crew should look for:

- Symbols, words, or other marks on the drum indicating that its contents are hazardous, e.g., radioactive, explosive, corrosive, toxic, flammable.
- Symbols, words, or other marks on a drum indicating that it contains discarded laboratory chemicals, reagents, or other potentially dangerous materials in small-volume individual containers (see Table 11-1).
- Signs of deterioration such as corrosion, rust, and leaks.
- Signs that the drum is under pressure such as swelling and bulging.
- Drum type (see Table 11-1).
- Configuration of the drumhead (see Table 11-2).

Conditions in the immediate vicinity of the drums may provide information about drum contents and their associated hazards. Monitoring should be conducted around the drums using instruments such as a gamma radiation survey instrument, organic vapor monitors, and a combustible gas meter.

The results of this survey can be used to classify the drums into preliminary hazard categories, for example:

- Radioactive.
- Leaking/deteriorated.
- Bulging.
- Explosive/shock-sensitive.
- Contains small-volume individual containers of laboratory wastes or other dangerous materials.

As a precautionary measure, personnel should assume that unlabelled drums contain hazardous materials until their contents are characterized. Also, they should bear in mind that drums are frequently mislabeled-particularly drums that are reused. Thus, a drum's label may not accurately describe its contents.

If buried drums are suspected, ground-penetrating systems, such as electromagnetic wave, electrical resistivity, ground-penetrating radar, magnetometry, and metal detection, can be used to estimate the location and depth of the drums. Table 11-1. Special Drum Types and Their Associated Hazards

Planning

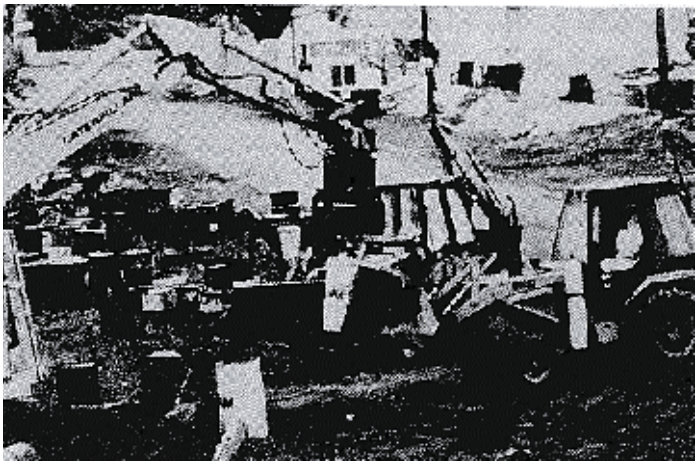
Since drum handling is fraught with danger, every step of the operation should be carefully planned, based on all the information available at the time. The results of the preliminary inspection can be used to determine (1) if any hazards are present and the appropriate response, and (2) which drums need to be moved in order to be opened and sampled. A preliminary plan should be developed which specifies the extent of handling necessary, the personnel selected for the job, and the most appropriate procedures based on the hazards associated with the probable drum contents as determined by visual inspection. This plan should be revised as new information is obtained during drum handling.

Table 11-1. Special Drum Types and Their Associated Hazards

Polyethylene or PVC-Lined Drums	Often contain strong acids or bases. If the lining is punctured, the substance usually quickly corrodes the steel, resulting in a significant leak or spill.
Exotic Metal Drums (e.g., aluminum, nickel, stainless steel, or other unusual metal)	Very expensive drums that usually contain an extremely dangerous material.
Single-Walled Drums Used as a Pressure Vessel	These drums have fittings for both product filling and placement of an inert gas, such as nitrogen. May contain reactive, flammable, or explosive substances.
Laboratory Packs	Used for disposal of expired chemicals and process samples from university laboratories, hospitals, and similar institutions. Individual containers within the lab pack are often not packed in absorbent material. They may contain incompatible materials, radioisotopes, shock-sensitive, highly volatile, highly corrosive, or very toxic exotic chemicals. Laboratory packs can be an ignition source for fires at hazardous waste sites.

Handling

The purpose of handling is to (1) respond to any obvious problems that might impair worker safety, such as radioactivity, leakage, or the presence of explosive substances, (2) unstack and orient drums for sampling, and (3) if necessary, to organize drums into different areas on site to facilitate characterization and remedial action (see *Staging* in this chapter). Handling may or may not be necessary, depending on how the drums are positioned at a site.



Backhoe with drum grappler.

Since accidents occur frequently during handling, particularly initial handling, drums should only be handled if necessary. Prior to handling, all personnel should be warned about the hazards of handling, and instructed to minimize handling as much as possible and to avoid unnecessary handling. In all phases of handling, personnel should be alert for new information about potential hazards. These hazards should be responded to before continuing with more routine handling operations. Overpack drums (larger drums in which leaking or damaged drums are placed for storage or shipment [see 49 CFR Part 173.3(c)]) and an adequate volume of absorbent should be kept near areas where minor spills may occur. Where major spills may occur, a containment berm adequate to contain the entire volume of liquid in the drums should be constructed before any handling takes place. If the drum contents spill, personnel trained in spill response should be used to isolate and contain the spill.

Several types of equipment can be used to move drums: (1) A drum grappler attached to a hydraulic excavator; (2) a small front-end loader, which can be either loaded manually or equipped with a bucket sling; (3) a rough terrain forklift; (4) a roller conveyor equipped with solid rollers; and (5) drum carts designed specifically for drum handling. Drums are also sometimes moved manually. The drum grappler is the preferred piece of equipment for drum handling. It keeps the operator removed from the drums so that there is less likelihood of injury if the drums detonate or rupture. If a drum is leaking, the operator can stop the leak by rotating the drum and immediately placing it into an overpack. In case of an explosion, grappler claws help protect the operator by partially deflecting the force of the explosion.

The following procedures can be used to maximize worker safety during drum handling and movement:

- Train personnel in proper lifting and moving techniques to prevent back injuries.
- Make sure the vehicle selected has sufficient rated load capacity to handle the anticipated loads, and make sure the vehicle can operate smoothly on the available road surface.
- Air condition the cabs of vehicles to increase operator efficiency; protect the operator with heavy splash shields.
- Supply operators with appropriate respiratory protective equipment when needed. Normally either a combination SCBA/SAR with the air tank fastened to the vehicle, or an airline respirator and an escape SCBA are used because of the high potential hazards of drum handling. This improves operator efficiency and provides protection in case the operator must abandon the equipment.
- Have overpacks ready before any attempt is made to move drums.
- Before moving anything, determine the most appropriate sequence in which the various drums and other containers should be moved. For example, small containers may have to be removed first to permit heavy equipment to enter and move the drums.
- Exercise extreme caution in handling drums that are not intact and tightly sealed.
- Ensure that operators have a clear view of the roadway when carrying drums. Where necessary, have ground workers available to guide the operator's motion.

Drums Containing Radioactive Waste

- If the drum exhibits radiation levels above background (see Table 6-2) immediately contact a health physicist. Do *not* handle any drums that are determined to be radioactive until persons with expertise in this area have been consulted.

Drums that May Contain Explosive or Shock-Sensitive Waste

- If a drum is suspected to contain explosive or shock-sensitive waste as determined by visual inspection, seek specialized assistance before any handling.
- If handling is necessary, handle these drums with *extreme caution*.
- Prior to handling these drums, make sure all nonessential personnel have moved a safe distance away.
- Use a grappler unit constructed for explosive containment for initial handling of such drums.
- Palletize the drums prior to transport. Secure drums to pallets.
- Use an audible siren signal system, similar to that employed in conventional blasting operations, to signal the commencement and completion of explosive waste handling activities.
- Maintain continuous communication with the Site Safety Officer and/or the command post until drum handling operations are complete.

Bulging Drums

- Pressurized drums are extremely hazardous. Wherever possible, do not move drums that may be under internal pressure, as evidenced by bulging or swelling.
- If a pressurized drum has to be moved, whenever possible handle the drum with a grappler unit constructed for explosive containment. Either move the bulged drum only as far as necessary to allow seating on firm ground, or carefully overpack the drum. Exercise extreme caution when working with or adjacent to potentially pressurized drums.

Drums Containing Packaged Laboratory Wastes (Lab Packs)

Laboratory packs (i.e., drums containing individual containers of laboratory materials normally surrounded by cushioning absorbent material) can be an ignition source for fires at hazardous waste sites. They sometimes contain shock-sensitive materials. Such containers should be considered to hold explosive or shock-sensitive wastes until otherwise characterized. If handling is required, the following precautions are among those that should be taken:

- Prior to handling or transporting lab packs, make sure all non-essential personnel have moved a safe distance away.
- Whenever possible, use a grappler unit constructed for explosive containment for initial handling of such drums.
- Maintain continuous communication with the Site Safety Officer and/or the command post until handling operations are complete.
- Once a lab pack has been opened, have a chemist inspect, classify, and segregate the bottles within it, without opening them, according to the hazards of the wastes. An example of a system for classifying lab pack wastes is provided in Table 11-3. The objective of a classification system is to ensure safe segregation of the lab packs' contents. Pack these bottles with sufficient cushioning and absorption materials to prevent excessive movement of the bottles and to absorb all free liquids, and ship them to an approved disposal facility.
- If crystalline material is noted at the neck of any bottle, handle it as a shock-sensitive waste, due to the potential presence of picric acid or other similar material, and get expert advice before attempting to handle it.
- Palletize the repacked drums prior to transport. Secure the drums to pallets.

Leaking, Open, and Deteriorated Drums

- If a drum containing a liquid cannot be moved without rupture, immediately transfer its contents to a sound drum using a pump designed for transferring that liquid.
- Using a drum grappler, place immediately in overpack containers:
- Leaking drums that contain sludges or semi-solids.
- Open drums that contain liquid or solid waste.
- Deteriorated drums that can be moved without rupture.

Buried Drums

- Prior to initiating subsurface excavation,

use ground penetrating systems to estimate the location and depth of the drums (see *Inspection* in this chapter).

- Remove soil with great caution to minimize the potential for drum rupture.
- Have a dry chemical fire extinguisher on hand to control small fires.

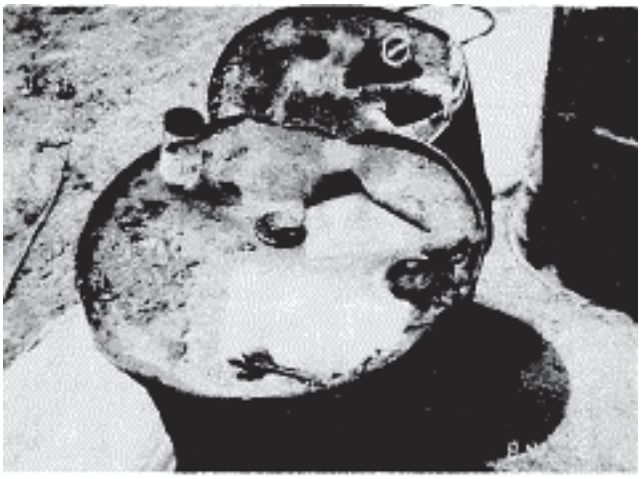
Table 11-3. Example of Lab Pack Content Classification System for Disposal

CLASSIFICATION	EXAMPLES
Inorganic acids	Hydrochloric Sulfuric
Inorganic bases	Sodium hydroxide Potassium hydroxide
Strong oxidizing agents	Ammonium nitrate Barium nitrate Sodium chlorate Sodium peroxide
Strong reducing agents	Sodium thiosulfate Oxalic acid Sodium sulphite
Anhydrous organics and organometallics	Tetraethyl lead Penylmercuric chloride
Anhydrous inorganics and metal hydrides	Potassium hydride Sodium hydride Sodium metal Potassium
Toxic organics	PCBs Insecticides
Flammable organics	Hexane Toluene Acetone
Inorganics	Sodium carbonate Potassium chloride
Inorganic cyanides	Potassium cyanide Sodium cyanide Copper cyanide
Organic Cyanides	Cyanoacetamide
Toxic metals	Arsenic Cadmium Lead Mercury

Opening

Drums are usually opened and sampled in place during site investigations. However, remedial and emergency operations may require a separate drum opening area (see *Staging* in this chapter). Procedures for opening drums are the same, regardless of where the drums are opened. To enhance the efficiency and safety of drum-opening personnel, the following procedures should be instituted.

- If a supplied-air respiratory protection system is used, place a bank of air cylinders outside the work area and supply air to the operators via airlines and escape SCBAs. This enables workers to operate in relative comfort for extended periods of time.
- Protect personnel by keeping them at a safe distance from the drums being opened. If personnel must be located near the drums, place explosion-resistant plastic shields between them and the drums to protect them in case of detonation. Locate controls for drum opening equipment, monitoring equipment, and fire suppression equipment behind the explosion resistant plastic shield.
- If possible, monitor continuously during opening. Place sensors of monitoring equipment, such as colorimetric tubes, dosimeters, radiation survey instruments, explosion meters, organic vapor analyzers, and oxygen meters, as close as possible to the source of contaminants, i.e., at the drum opening.
- Use the following remote-controlled devices for opening drums:
  - Pneumatically operated impact wrench to remove drum bungs.
  - Hydraulically or pneumatically operated drum piercers (see Figure 11-2).
  - Backhoes equipped with bronze spikes for penetrating drum tops in large-scale operations (see Figure 11-3).
- Do not use picks, chisels and firearms to open drums.
- Hang or balance the drum opening equipment to minimize worker exertion.
- If the drum shows signs of swelling or bulging, perform all steps slowly. Relieve excess pressure prior to opening and, if possible, from a remote location using such devices as a pneumatic impact wrench or hydraulic penetration device. If pressure must be relieved manually, place a barrier such as explosion-resistant plastic sheeting between the worker and bung to deflect any gas, liquid, or solids which may be expelled as the bung is loosened.
- Open exotic drums and polyethylene or polyvinyl chloride-lined (PVC-lined) drums through the bung by removal or drilling. Exercise extreme caution when manipulating these containers.
- Do not open or sample individual containers within laboratory packs.
- Reseal open bungs and drill openings as soon as possible with new bungs or plugs to avoid explosions and/or vapor generation. If an open drum cannot be resealed, place the drum into an overpack. Plug any openings in pressurized drums with pressure-venting caps set to a 5-psi (pounds per square inch) release to allow venting of vapor pressure.
- Decontaminate equipment after each use to avoid mixing incompatible wastes.



Two drums with rusted bungs were opened by backhoes with bronze spikes and now await sampling. Drum in foreground has been labeled “150” for sample documentation purposes.

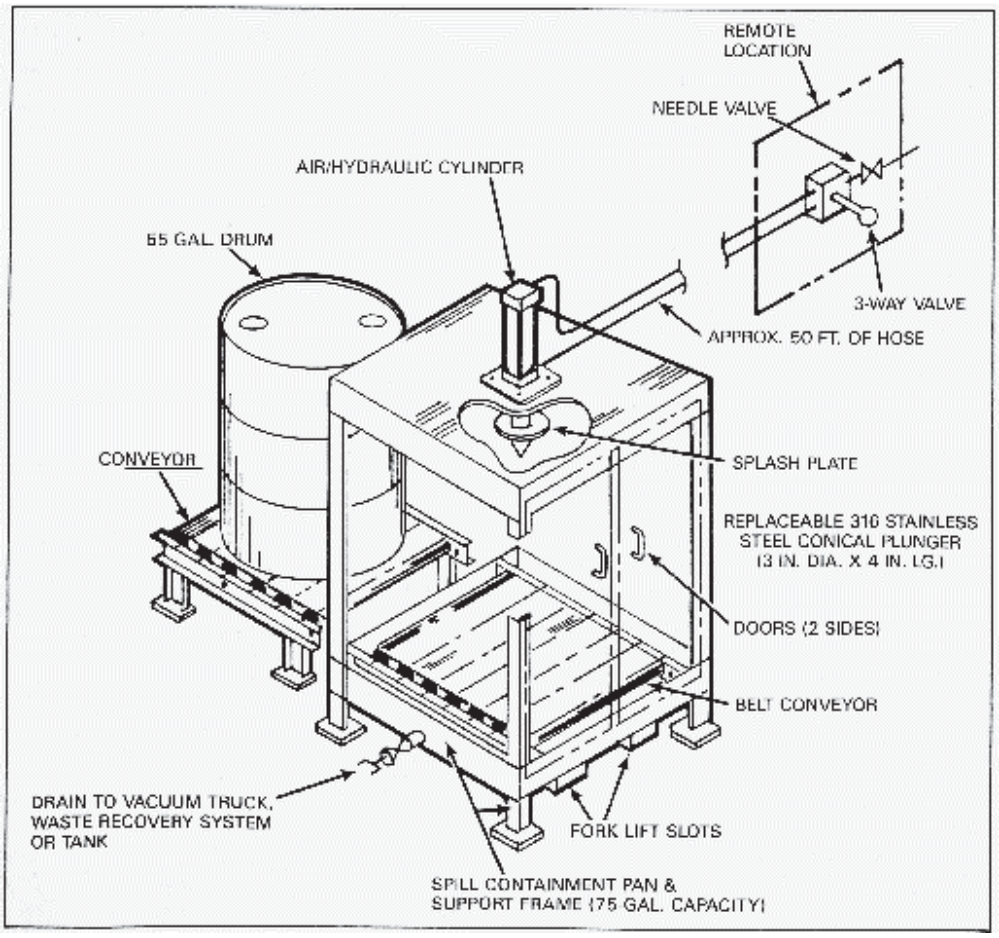


Figure 11-2. Air/Hydraulic-Operated Single-Drum Puncture Device. Source: Reference [1].

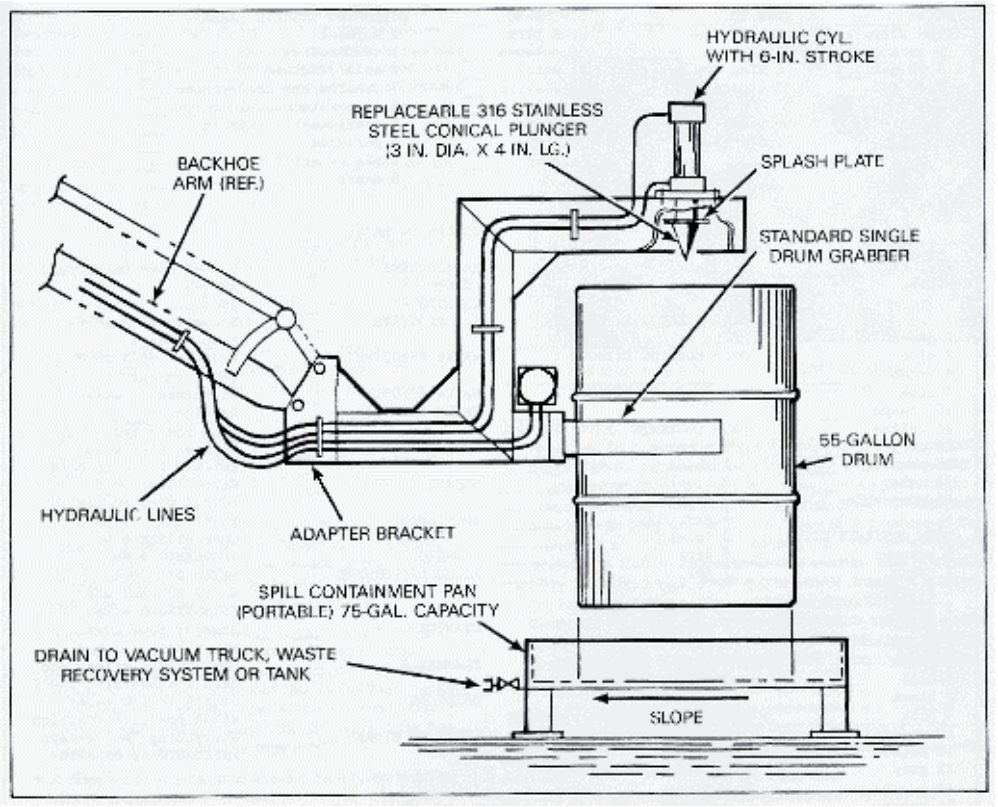


Figure 11-3. Backhoe-Mounted Drum Puncture Device. Source: Reference [1].

Sampling

Drum sampling can be one of the most hazardous activities to worker safety and health because it often involves direct contact with unidentified wastes. Prior to collecting any sample, develop a sampling plan:

- Research background information about the waste.
- Determine which drums should be sampled.
- Select the appropriate sampling device(s) and containers.
- Develop a sampling plan which includes the number, volume, and locations of samples to be taken.
- Develop Standard Operating Procedures for opening drums, sampling, and sample packaging and transportation. Some guidance in designing proper sampling procedures can be found in References [2] and [3].
- Have a trained health and safety professional determine, based on available information about the wastes and site conditions, the appropriate personal protection to be used during sampling, decontamination, and packaging of the sample.

When manually sampling from a drum, use the following techniques:

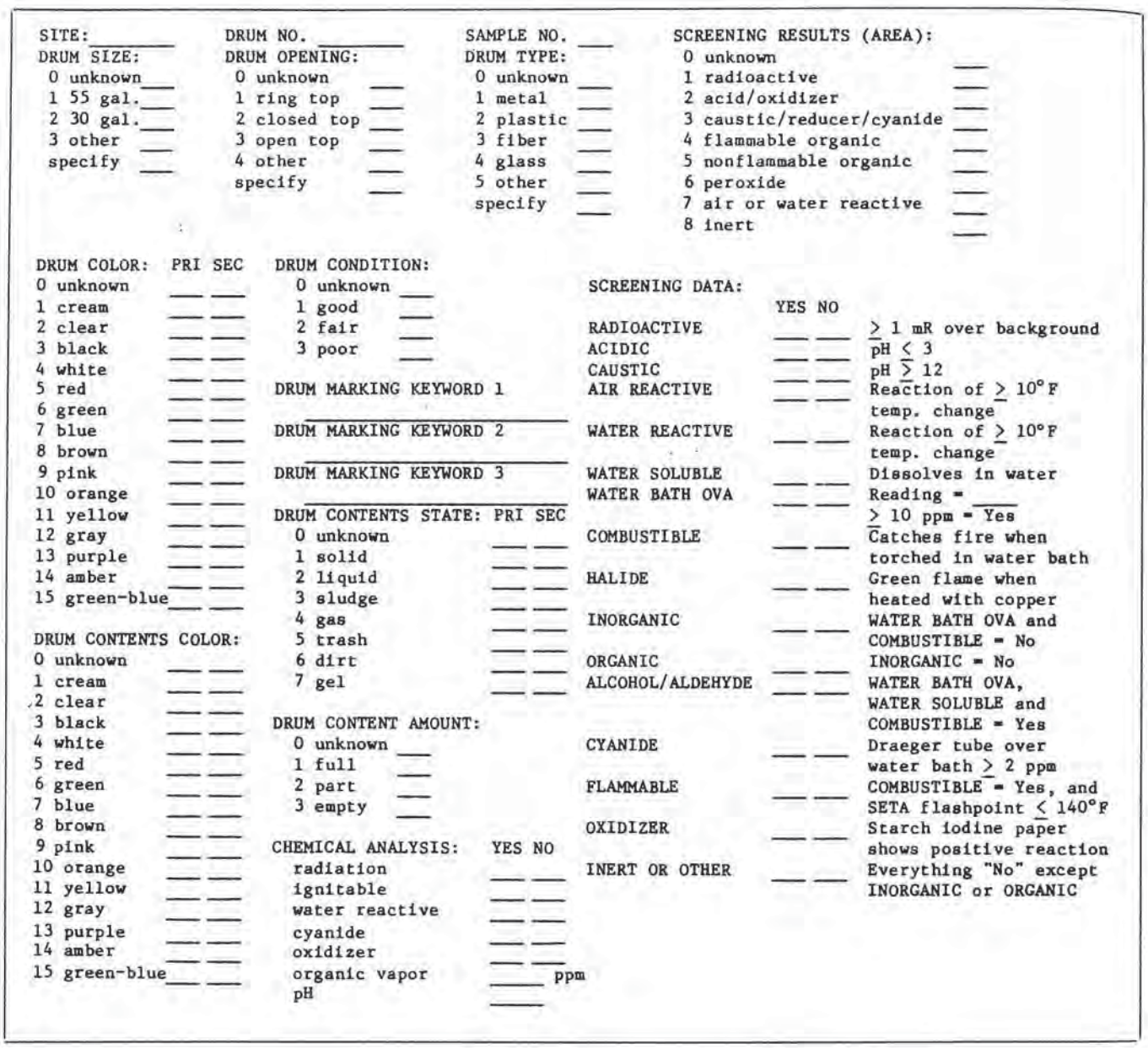
- Keep sampling personnel at a safe distance while drums are being opened. Sample only after opening operations are complete.
- Do *not* lean over other drums to reach the drum being sampled, unless absolutely necessary.
- Cover drum tops with plastic sheeting or other suitable non-contaminated materials to avoid excessive contact with the drum tops.
- *Never* stand on drums. This is extremely dangerous. Use mobile steps or another platform to achieve the height necessary to safely sample from the drums.
- Obtain samples with either glass rods or vacuum pumps. Do *not* use contaminated items such as discarded rags to sample. The contaminants may contaminate the sample and may not be compatible with the waste in the drum. Glass rods should be removed prior to pumping to minimize damage to pumps.

Characterization

The goal of characterization is to obtain the data necessary to determine how to safely and efficiently package and transport the wastes for treatment and/or disposal. If wastes are bulked, they must be sufficiently characterized to determine which of them can be safely combined (see *Bulking* later in this chapter). As a first step in obtaining these data, standard tests should be used to classify the wastes into general categories, including auto-reactives, water reactives, inorganic acids, organic acids, heavy metals, pesticides, cyanides, inorganic oxidizers, and organic oxidizers. In some cases, further analysis should be conducted to more precisely identify the waste materials. See Figure 11-4 for an example of a characterization sheet for drums.

When possible, materials should be characterized using an onsite laboratory. This provides data as rapidly as possible, and minimizes the time lag before appropriate action can be taken to handle any hazardous materials. Also, it precludes any potential problems associated with transporting samples to an offsite laboratory (e.g., sample packaging, waste incompatibility, fume generation).

If samples must be analyzed off site, samples should be packaged on site in accordance with DOT regulations (49 CFR) and shipped to the laboratory for analysis.



SITE: _____
DRUM SIZE:
0 unknown ___
1 55 gal. ___
2 30 gal. ___
3 other ___
specify ___

DRUM NO. _____
DRUM OPENING:
0 unknown ___
1 ring top ___
2 closed top ___
3 open top ___
4 other ___
specify ___

SAMPLE NO. ___
DRUM TYPE:
0 unknown ___
1 metal ___
2 plastic ___
3 fiber ___
4 glass ___
5 other ___
specify ___

SCREENING RESULTS (AREA):
0 unknown ___
1 radioactive ___
2 acid/oxidizer ___
3 caustic/reducer/cyanide ___
4 flammable organic ___
5 nonflammable organic ___
6 peroxide ___
7 air or water reactive ___
8 inert ___

DRUM COLOR: PRI SEC
0 unknown ___ ___
1 cream ___ ___
2 clear ___ ___
3 black ___ ___
4 white ___ ___
5 red ___ ___
6 green ___ ___
7 blue ___ ___
8 brown ___ ___
9 pink ___ ___
10 orange ___ ___
11 yellow ___ ___
12 gray ___ ___
13 purple ___ ___
14 amber ___ ___
15 green-blue ___ ___

DRUM CONTENTS COLOR:
0 unknown ___ ___
1 cream ___ ___
2 clear ___ ___
3 black ___ ___
4 white ___ ___
5 red ___ ___
6 green ___ ___
7 blue ___ ___
8 brown ___ ___
9 pink ___ ___
10 orange ___ ___
11 yellow ___ ___
12 gray ___ ___
13 purple ___ ___
14 amber ___ ___
15 green-blue ___ ___

DRUM CONDITION:
0 unknown ___
1 good ___
2 fair ___
3 poor ___

DRUM MARKING KEYWORD 1
_____

DRUM MARKING KEYWORD 2
_____

DRUM MARKING KEYWORD 3
_____

DRUM CONTENTS STATE: PRI SEC
0 unknown ___ ___
1 solid ___ ___
2 liquid ___ ___
3 sludge ___ ___
4 gas ___ ___
5 trash ___ ___
6 dirt ___ ___
7 gel ___ ___

DRUM CONTENT AMOUNT:
0 unknown ___
1 full ___
2 part ___
3 empty ___

CHEMICAL ANALYSIS: YES NO
radiation ___ ___
ignitable ___ ___
water reactive ___ ___
cyanide ___ ___
oxidizer ___ ___
organic vapor _____ ppm
pH _____

SCREENING DATA:

	YES	NO	
RADIOACTIVE	___	___	≥ 1 mR over background
ACIDIC	___	___	pH ≤ 3
CAUSTIC	___	___	pH ≥ 12
AIR REACTIVE	___	___	Reaction of ≥ 10°F temp. change
WATER REACTIVE	___	___	Reaction of ≥ 10°F temp. change
WATER SOLUBLE	___	___	Dissolves in water
WATER BATH OVA	___	___	Reading = ____ ≥ 10 ppm = Yes
COMBUSTIBLE	___	___	Catches fire when torched in water bath
HALIDE	___	___	Green flame when heated with copper
INORGANIC	___	___	WATER BATH OVA and COMBUSTIBLE = No
ORGANIC	___	___	INORGANIC = No
ALCOHOL/ALDEHYDE	___	___	WATER BATH OVA, WATER SOLUBLE and COMBUSTIBLE = Yes
CYANIDE	___	___	Draeger tube over water bath ≥ 2 ppm
FLAMMABLE	___	___	COMBUSTIBLE = Yes, and SETA flashpoint ≤ 140°F
OXIDIZER	___	___	Starch iodine paper shows positive reaction
INERT OR OTHER	___	___	Everything "No" except INORGANIC or ORGANIC

Figure 11-4. Sample Drum Characterization Sheet. Source: EPA Region VII Emergency Planning and Response Branch. (This figure is provided only as an example. Values were selected by EPA Region VII and should be modified as appropriate.

Staging

Although every attempt should be made to minimize drum handling, drums must sometimes be staged (i.e. moved in an organized manner to predesignated areas) to facilitate characterization and remedial action, and to protect drums from potentially hazardous site conditions (e.g., movement of heavy equipment and high temperatures that might cause explosion, ignition, or pressure buildup). Staging involves a trade-off between the increased hazards associated with drum movement and the decreased hazards associated with the enhanced organization and accessibility of the waste materials.

The number of staging areas necessary depends on sitespecific circumstances such as the scope of the operation, the accessibility of drums in their original positions, and the perceived hazards. Investigation usually involves little, if any, staging; remedial and emergency operations can involve extensive drum staging. The extent of staging must be determined individually for each site, and should always be kept to a minimum. Up to five separate areas have been used (see Figure 11-5):

- An *initial staging area* where drums can be (1) organized according to type, size, and suspected contents, and (2) stored prior to sampling.
- An *opening area* where drums are opened, sampled, and resealed. Locate this area a safe distance from the original waste disposal or storage site and from all staging areas to prevent a chain reaction in case of fire or explosion.
- During large-scale remedial or emergency tasks, a separate *sampling area* may be set up at some distance from the opening area to reduce the number of people present in the opening area, and to limit potential casualties in case of an explosion
- A *second staging area*, also known as a holding area, where drums are temporarily stored after sampling pending characterization of their contents. Do *not* place unsealed drums with unknown contents in the second staging area in case they contain incompatible materials. (Either remove the contents or overpack the drum.)
- A *final staging area*, also known as a bulking area, where substances that have been characterized are bulked for transport to treatment or disposal facilities.
    - Locate the final staging area as close as possible to the site's exit.
    - Grade the area and cover it with plastic sheeting. Construct approximately 1-foot-high (0.3-m-high) dikes around the entire area.
    - Segregate drums according to their basic chemical categories (acids, heavy metals, pesticides, etc.) as determined by characterization. Construct separate areas for each type of waste present to preclude the possibility of intermingling incompatible chemicals when bulking.

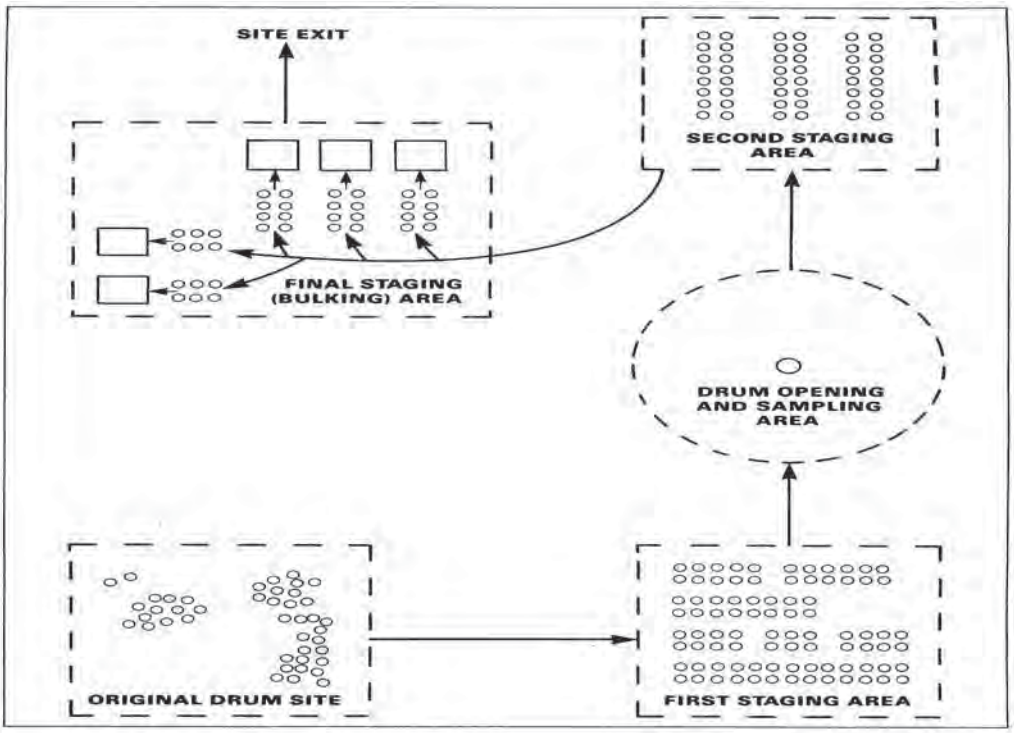


Figure 11-5. Possible Staging Areas at a Hazardous Waste Site.

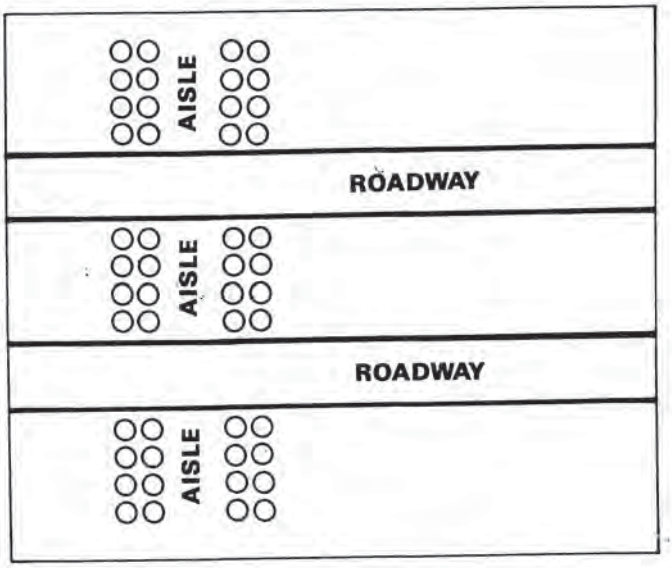


Figure 11-6. Sample Drum Staging Layout. Source: Reference [1].

Bulking

Wastes that have been characterized are often mixed together and placed in bulk containers such as tanks or vacuum trucks for shipment to treatment or disposal facilities. This increases the efficiency of transportation. Bulking should be performed only after thorough waste characterization by trained and experienced personnel. The preliminary tests described earlier under *Characterization* provide only a general indication of the nature of the individual wastes. In most cases, additional sampling and analysis to further characterize the wastes, and compatibility tests (in which small quantities of different wastes are mixed together under controlled conditions and observed for signs of incompatibility such as vapor generation and heat of reaction) should be conducted. Bulking is performed at the final staging area using the following procedures:

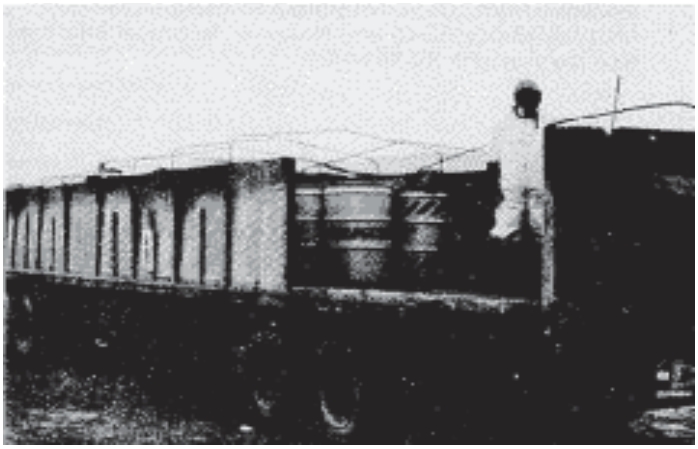
Crushed drums awaiting landfill. Note the staging of drums on the left in a row two drums wide.

- Inspect each tank trailer and remove any residual materials from the trailer prior to transferring any bulked materials. This will prevent reactions between incompatible chemicals.
- To move hazardous liquids, use pumps that are properly rated (see National Fire Protection Association [NFPA] 70 Articles 500-503 and NFPA 497M) and that have a safety relief valve with a splash shield. Make sure the pump hoses, casings, fittings, and gaskets are compatible with the material being pumped.
- Inspect hose lines before beginning work to ensure that all lines, fittings, and valves are intact with no weak spots.
- Take special precautions when handling hoses as they often contain residual material that can splash or spill on the personnel operating the hoses. Protect personnel against accidental splashing. Protect lines from vehicular and pedestrian traffic.
- Store flammable liquids in approved containers.

Shipment

Shipment of materials to offsite treatment, storage, or disposal facilities involves the entry of waste hauling vehicles into the site. U.S. Department of Transportation (DOT) regulations (49 CFR Parts 171-178) and EPA regulations (40 CFR Part 263) for shipment of hazardous wastes must be complied with. The following guidelines can enhance the safety of these operations:

- Locate the final staging (bulking) area as close as possible to the site exit.
- Prepare a circulation plan that minimizes conflict between cleanup teams and waste haulers. Install traffic signs, lights, and other control devices as necessary.
- Provide adequate area for onsite and hauling vehicles to turn around. Where necessary, build or improve onsite roads.
- Stage hauling vehicles in a safe area until ready for loading with drivers remaining in cab. Minimize the time that drivers spend in hazardous areas.
- Outfit the driver with appropriate protective equipment.
- If drums are shipped, tightly seal the drums prior to loading. Overpack leaking or deteriorated drums prior to shipment. (Under most circumstances, overpack drums used for hazardous wastes may not be reused [49 CFR Part 173.3(c)]). Make sure that truck bed and walls are clean and smooth to prevent damage to drums. Do not double stack drums. Secure drums to prevent shifting during transport.
- Keep bulk solids several inches below the top of the truck container. Cover loads with a layer of clean soil, foam, and/or tarp. Secure the load to prevent shifting or release during transport.
- Weigh vehicles periodically to ensure that vehicle and road weight limits are not exceeded.
- Decontaminate vehicle tires prior to leaving the site to ensure that contamination is not carried onto public roads.
- Check periodically to ensure that vehicles are not releasing dust or vapor emissions off site.
- Develop procedures for responding quickly to offsite vehicle breakdown and accidents to ensure minimal public impact.



Single-stacked overpack drums awaiting transport off site. Worker suited in Level C personal protective equipment will spread a tarp over the drums to protect them during transport.

Special Case Problems

Tanks and Vaults

For tanks and vaults, which are often found on hazardous waste sites, the following procedures are recommended:

- In general, when opening a tank or vault follow the same procedures as for a sealed drum. If necessary, vent excess pressure if volatile substances are stored. Place deflecting shields

between workers and the opening to prevent direct contamination of workers by materials forced out by pressure when the tank is opened.

- Guard manholes or access portals to prevent personnel from falling into the tank.
- Identify the contents through sampling and analysis. If characterization indicates that the contents can be safely moved with the available equipment, vacuum them into a trailer for transportation to a disposal or recycling facility.
- Empty and decontaminate the tank or vault before disposal.
- If it is necessary to enter a tank or vault (i.e., confined spaces) for any reason (e.g., to clean off solid materials or sludges on the bottom or sides of the tank or vault), the following precautions should be taken [4]:
  - Ventilate thoroughly prior to entry.
  - Disconnect connecting pipelines.
  - Prior to entry, take air samples to prove the absence of flammable or other hazardous vapors and to demonstrate that adequate levels of oxygen exist.
  - Equip the entry team with appropriate respiratory protection, protective clothing, safety harnesses, and ropes.
  - Equip a safety observer with appropriate respiratory protection, protective clothing, a safety harness, and ropes.
  - Establish lifeline signals prior to entry so that the worker and safety observer can communicate by tugs on the rope.
  - Have an additional person available in the immediate vicinity to assist the safety observer if needed.
  - Instruct the safety observer not to enter the space until additional personnel are on scene.

Vacuum Trucks

- Wear appropriate protective clothing and equipment when opening the hatch.
- If possible, use mobile steps or suitable scaffolding consistent with 29 CFR Part 1910 Subpart D. Avoid climbing up the ladder and walking across the tank catwalk.
- If the truck must be climbed, raise and lower equipment and samples in carriers to enable workers to use two hands while climbing.
- If possible, sample from the top of the vehicle. If it is necessary to sample from the drain spigot, take steps to prevent spraying of excessive substances. Have all personnel stand off to the side. Have sorbent materials on hand in the event of a spill.

Elevated Tanks

In general, observe the safety precautions described for vacuum trucks. In addition:

- Use a safety line and harness.
- Maintain ladders and railings in accordance with OSHA requirements (29 CFR Part 1910 Subpart D).

Compressed Gas Cylinders

- Obtain expert assistance in moving and disposing of compressed gas cylinders.
- Handle compressed gas cylinders with extreme caution. The rupture of a cylinder may result in an explosion, and the cylinder may become a dangerous projectile.
- Record the identification numbers on the cylinders to aid in characterizing their contents.

Ponds and Lagoons

- Drowning is a very real danger for personnel suited in protective equipment because the weight of protective equipment increases an individual's overall density and severely impairs their

swimming ability. Where there is danger of drowning, provide necessary safety gear such as lifeboats, tag lines, railings, nets, safety harnesses, and flotation gear.

- Wherever possible, stay on shore. Avoid going out over the water.
- Be aware that some solid wastes may float and give the appearance of solid cracked mud. Caution should be exercised when working along shorelines.

References

1. Mayhew, Joe J.; G.M. Sodear; and D.W. Carroll. 1982. A Hazardous Waste Site Management Plan. Chemical Manufacturers Association, Inc., Washington DC.

2. deVera, E.R.; B.R Simmons; R.D. Stephens; and D.L. Storm. 1980. Samplers and Sampling Procedures for Hazardous Waste Streams. EPA-600/2-80-018. U.S. Environmental Protection Agency, Cincinnati, OH.

3. U.S. EPA. 1984. Characterization of Hazardous Waste Sites-A Methods Manual: Volume II. Available Sampling Methods. Second edition. EPA 600/ 4-84-076.

4. NIOSH. 1979. Criteria for a Recommended Standard: Working in Confined Spaces. NIOSH No. 80-106. Also available from U.S. Government Printing Office (#017-033-00353-0) and National Technical Information Service (PB-80-183015).

APPENDIX E
WASTE FORMS

NON-HAZARDOUS WASTE MANIFEST

Please print or type (Form designed for use on elite (12-pitch) typewriter

NON-HAZARDOUS WASTE MANIFEST	1. Generator's US EPA ID No. N/A	Manifest Document No.	2. Page 1 Of 1

3. Generator's Name and Mailing Address 4. Generators Phone	Bill to: NA ATTN: NA

5. Transporter 1 Company Name	6. US EPA ID Number N/A	A. State Transporter's ID N/A	
		B. Transporter 1 Phone	
7. Transporter 2 Company Name	8. US EPA ID Number N/A	C. State Transporter's ID N/A	
		D. Transporter 2 Phone	
9. Designated Facility Name and Site Address	10. US EPA ID Number NA	E. State Facility's ID	
		F. Facility's Phone	

GENERATOR

HM	11. WASTE DESCRIPTION	12. Containers No.	12. Containers Type	13. Total Quantity	14. Unit Wt./Vol.

G. Additional Descriptions for Materials Listed Above	H. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information

16. GENERATOR'S CERTIFICATION: I hereby certify that the contents of this shipment are fully and accurately described and are in all respects in proper condition for transport. The materials described on this manifest are not subject to federal hazardous waste regulation.

Printed/Typed Name	Signature	Date: Month	Date	Year

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Name	Signature	Date: Month	Date	Year

18. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Name	Signature	Date: Month	Date	Year

FACILITY

19. Discrepancy Indication Space

20. Facility Owner or Operator, Certification of receipt of the waste materials covered by this manifest, except as noted in item 19.

Printed/Typed Name	Signature	Date: Month	Date	Year

Please print or type. (Form designed for use on elite (12-pitch) typewriter.) Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator ID Number	2. Page 1 of	3. Emergency Response Phone	4. Manifest Tracking Number

GENERATOR

5. Generator's Name and Mailing Address

Generator's Site Address (if different than mailing address)

Generator's Phone:

6. Transporter 1 Company Name — U.S. EPA ID Number

7. Transporter 2 Company Name — U.S. EPA ID Number

8. Designated Facility Name and Site Address — U.S. EPA ID Number

Facility's Phone:

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
	1.					
	2.					
	3.					
	4.					

14. Special Handling Instructions and Additional Information

15. **GENERATOR'S/OFFEROR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name — Signature — Month Day Year

INT'L

16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit:

Transporter signature (for exports only): Date leaving U.S.:

TRANSPORTER

17. Transporter Acknowledgment of Receipt of Materials

Transporter 1 Printed/Typed Name — Signature — Month Day Year

Transporter 2 Printed/Typed Name — Signature — Month Day Year

DESIGNATED FACILITY

18. Discrepancy

18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection

Manifest Reference Number:

18b. Alternate Facility (or Generator) — U.S. EPA ID Number

Facility's Phone:

18c. Signature of Alternate Facility (or Generator) — Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1.	2.	3.	4.

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a

Printed/Typed Name — Signature — Month Day Year