APPENDIX A

Cabrera Services, Inc. Standard Operating Procedures

LIST OF SOPs

Radiation Safety Procedure for ALARA AP-005 Revision 1

Radiation Safety Procedure for Radiological Surveys OP-001 Revision 1

Radiation Safety Procedure for Air Sampling and Analysis OP-002 Revision 0

Radiation Safety Procedure for Use and Control Radioactive Check Sources OP-009 Revision 0

Radiation Safety Procedure for Decontamination of Equipment and Tools OP-018 Revision 0

Radiation Safety Procedure for Alpha -Beta Counting Instrumentation OP-021 Revision 0

Radiation Safety Procedure for Operation of Contamination Survey Meters OP-O20 Revision 0

Radiation Safety Procedure for Operation of Micro-R Meters OP-O23 Revision 0

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

RADIATION SAFETY PROCEDURE

FOR

ALARA

AP-005

REVISION 1

Approved by: _____ Date: 4/13/06

Henry Siegrist, CHP, PE, Corporate Health Physicist

Approved by: _____ Date: 4/13/06

Dave Watters, CHP, Senior Vice President, Operations

1.0 PURPOSE

This procedure provides the requirements and methods Cabrera Services, Inc. (CABRERA) personnel shall 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 or Corp. HP (RSO or Corp. HP). 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 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

3.1 Precautions

Not applicable.

3.2 Limitations

Not applicable.

3.3 Requirements

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

3.3.2 Documents created from use of this procedure shall be in accordance with AP-001.

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

4.0 REFERENCES

- 10 CFR 20 Standards for Protection Against Radiation
- CABRERA Health and Safety Program (HASP)
- CABRERA Radiation Safety Program (RSP)
- AP-001 Record Retention

5.0 DEFINITIONS AND ABBREVIATIONS

None.

6.0 EQUIPMENT

None required.

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 of ALARA principles and the use of this procedure. The RSO or Corp. HP is also responsible for reviewing and approving ALARA documents; and conducting, reviewing and/or approving ALARA reviews and briefings as described in this procedure.

7.2 Health Physics Technicians (HPT) - The HPT are responsible for the control of radioactive material, coverage of radiation workers, general safety protection and counseling workers to maintain exposures ALARA. 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 Project Radiation Safety Committee (RSC) - The RSC is responsible for high level review, evaluation, and action on ALARA issues that affect the Radiation Safety Program and review.

7.5 Project Technical Manager (TM) - The TM acts as the RSO's duly authorized representative for radiological issues when the RSO is not onsite. The TM shall perform the requirements established in this procedure, and ensure that they are implemented during field assignments.

7.6 Site Radiation Safety Officer (SRSO) - The SRSO acts as the RSO's and the TM'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 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 additional to those established in this procedure.

8.1.1 The RSO or Corp. HP shall discuss dose reduction techniques pertinent to project tasks that do not meet the criteria for formal reviews by this procedure with the PM, as necessary.

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

8.1.3 Dose rate reduction methods shall be identified and recorded prior to and during job performance.

8.2 Conducting ALARA Reviews and Briefings

8.2.1 Documented ALARA reviews and briefings for work conditions listed in Table AP-005-01 shall be in accordance with their associated risk factor listed in the same table.

TABLE AP-005-01: FORMAL ALARA JOB REVIEW AND BRIEFING REQUIREMENTS

WORK CONDITIONS	RISK FACTOR*	REVIEW CONDUCTED BY	REVIEW APPROVED BY	BRIEFING CONDUCTED BY
1. Any individual dose is expected to exceed 25 millirem (mrem). 2. The collective dose for the job exceeds 0.1 person rem.	1-5X	HPT/SRSO	RSO/ Corp. HP	HPT/SRSO
3. Airborne exposures exceed 12 DAC-hrs. per week for any single individual.	5-10X RSO/	Corp. HP RSO/	Corp. HP	SRSO/TM
4. General area dose rates exceed 1 mrem/hr. 5. Contamination levels exceed 100 times the values in "Surface Activity Guidelines" (AP-005-01)	>10X	HPT/SRSO	RSO/ Corp. HP	RSO/ Corp. HP
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.	These work conditions do not have risk factors associated with them, and shall be reviewed and approved by the RSO or Corp. HP in all instances.			

* 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/hour will determine that the RSO/Corp. HP will conduct and approve the review, and the briefing will be conducted by the HPT/SRSO).

8.2.2 A pre-job review (form supplied in Attachment AP-005-02) shall include the RWP, ALARA Review Form, survey records, previous job performance records, and technical work control documents, as appropriate.

8.2.3 The appropriate designee listed in Table AP-005-01 shall conduct job reviews and briefings. Periodic ALARA job-in-progress reviews shall be conducted if work conditions extend beyond one week. The PM shall provide any pertinent information regarding ALARA controls for the project.

8.2.4 Pre-job and job-in-progress briefings shall be performed and documented using the attached "ALARA Briefing Record" (supplied in Attachment AP-005-03) and the "ALARA Briefing Attendance Record" (supplied in Attachment AP-005-04).

8.2.5 Attendance at post-job reviews shall 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 shall, if practical, conduct the post-job review.

8.3 Review and Briefing Recordkeeping

8.3.1 All reviews shall be documented on the "Project ALARA Review Form" (supplied in Attachment AP-005-02).

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

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

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

8.3.5 Any information collected during the performance of the job that could reduce collective or individual dose rates for future work shall be documented on pages attached to the form.

8.3.6 Original copies of all documentation generated from use of this procedure shall be forwarded to the RSO or Corp. HP 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" (supplied in Attachment AP-005-01) or Report (supplied in Attachment AP-005-02), as appropriate.

9.0 ATTACHMENTS

- AP-005-01 Surface Activity Guidelines
- AP-005-02 Project ALARA Review Form
- AP-005-03 ALARA Briefing Record
- AP-005-04 ALARA Briefing Attendance Record

AP-005-01 -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.

AP-005-02 - 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	
	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	

AP-005-02 - Project ALARA Review Form (continued)

		REVIEW CRITERIA		ACTION	COMMENTS
PRE-JOB REVIEW	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	
	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	

AP-005-02 - Project ALARA Review Form (continued)

		REVIEW CRITERIA		ACTION	COMMENTS
PRE-JOB REVIEW	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	
	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	

AP-005-02 - Project ALARA Review Form (continued)

		REVIEW CRITERIA		ACTION	COMMENTS
PRE-JOB REVIEW	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	
	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	

AP-005-02 - Project ALARA Review Form (continued)

		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	
	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	

AP-005-02 - Project ALARA Review Form (continued)

		REVIEW CRITERIA		ACTION	COMMENTS
IN PROGRESS/POST-JOB REVIEW	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	
	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	

AP-005-02 - Project ALARA Review Form (continued)

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

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

_____

_____

_____

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

AP-005-03 - ALARA Briefing Record

RWP#: _____ Revision: _____ Start Date: _____

Task Description: _____

Radiation Safety: _____ (Print/Sign)

Project Manager: _____ (Print/Sign)

Site Radiation Safety Officer: _____ (Print/Sign)

1. The Site Radiation Safety Officer

AP-005-04 - ALARA Briefing Attendance Record

DATE	NAME		SSN/ID#	BRIEFING SUBJECT
	PRINT	SIGN		

Comments _____

_____

_____

_____

Instructor _____ (Print/Sign) Date _____

CABRERA SERVICES

Radiation Safety Procedure

For

Radiological Surveys

OP-001

Revision 1

Approved By: Henry Siegrist Date: 7/4/05

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

Approved By: David J Watters Date: 7/4/05

David Watters, CHP, Vice President Operations

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 maintain reproducible results. In addition, adherence to this procedure will provide adequate control of radiation exposures As Low As Reasonably Achievable (ALARA).

2.0 APPLICABILITY

This procedure provides the requirements 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. This procedure does not include survey requirements for radiation generating devices and survey requirements specified in radiation work permits (RWP's).

The following types of surveys may be performed using this procedure.

- Surveys for shipping radioactive materials (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.

3.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

3.1 Precautions

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

3.1.2 Large area smears may be used to augment (but not replace) the 100 cm^2 smear survey. Large area smears may be counted with a Ludlum Model-3 and 43-89 probe or equivalent. Large area smears 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.

3.1.3 Personnel performing routine surveys shall be logged in on a Radiation Work Permit in accordance with AP-012 (if applicable).

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

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

3.2 Limitations

3.2.1 The maximum probe speed during direct scan surveys of surfaces shall be 3 cm/sec.

3.2.2 The probe face shall 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.

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

3.2.4 Posting of radiological control areas shall be performed in accordance with OP-019.

3.3 Requirements

3.3.1 Individuals performing surveys should obtain and review any previous surveys performed in the area or on the object to determine radiation conditions which may be encountered.

3.3.2 Qualified individuals shall perform surveys. Qualification will be determined on a case basis by the Project Manager, RSO or duly authorized representative field. Qualification considers prior training, experience, and certifications such as, Health Physics Technician (HPT), NRRPT, etc.

3.3.3 To ensure achieving the required sensitivity of measurements, survey samples will be analyzed in a low-background area whenever practical.

3.3.4 Dose rate surveys, at a minimum, should 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 2.5 mrem/hr or more.

3.3.5 If contamination is found in unrestricted areas, prevent access to the area and immediately notify the RSO or duly authorized representative.

4.0 REFERENCES

- 10 CFR 20, Subpart E Radiological Criteria for License Termination
- 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 Personnel Protective Equipment
- OP-020 Operation of Contamination Survey Meters
- OP-021 Alpha-Beta Counting Instrumentation
- OP-022 Operation of Micro-R Meters
- OP-023 Operation of Ionization Chambers

5.0 DEFINITIONS AND ABBREVIATIONS

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

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 exposures as far below the federal limits as technical, economical and practical considerations permit.

6.0 EQUIPMENT

Instruments used to perform routine surveys shall be used in accordance with the applicable CABRERA administrative and operational procedures. Authorized suppliers of properly calibrated and maintained equipment will supply/calibrate instruments. Equipment counting efficiencies may be determined by qualified Cabrera personnel.

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

7.0 RESPONSIBILITIES

7.1 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.

7.2 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.

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 performing radiation and contamination surveys are responsible for knowing and complying with this procedure.

8.0 INSTRUCTIONS

8.1 Safety Considerations

The safety requirements specified in the job specific Health and Safety Plans and Work Plans, the Radiation Safety Program, and other safety documentation must be adhered to when performing surveys.

8.2 Initial Preparations

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

8.2.1 Obtain appropriate survey instruments and assure daily QC checks have been performed prior to instrument use.

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

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

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

8.3 Radiation Surveys

8.3.1 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.

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

8.3.2.1 Scan the entire surface area of the area, item, or container with a Micro-R or equivalent meter and record locations and readings on OP-001-02 or equivalent form.

8.3.2.2 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 OP-001-02 or equivalent form.

8.3.2.3 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 not covered by this procedure. Note readings on OP-001-02 or equivalent form.

8.3.3 Facility Surveys – This survey technique may be used to release 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.

8.3.3.1 Establish a 1 meter by 1 meter grid system of the facility surfaces using a marking system that assigns a unique number/letter system to the center of each grid. Graphically illustrate the location of the grid system on OP-001-02 or equivalent form.

8.3.3.2 Using a Micro-R Meter, obtain radiation levels at 1 meter from the grid center point and at contact with the grid center point. Record reading on OP-001-02 or equivalent Form. If elevated readings are noted, scan the surface of the grid

and note location of any elevated readings with a marker and on OP-001-02 or equivalent Form.

8.3.3.3 Obtain Micro-R 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 in step 8.3.3.2 above.

8.3.4 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

8.3.4.1 Establish a 10 meter by 10 meter grid system of the area to be surveyed using surveyor stakes or equivalent, which are numbered with a unique number/letter system to identify the center of each grid. List the locations of the "gridded" system on OP-001-02 or equivalent form.

8.3.4.2 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 OP-001-02 or equivalent Form.

8.3.4.3 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 subgrids and obtain readings at 1 meter above the ground surface. Record all readings on OP-001-02 or equivalent.

8.4 Contamination Surveys

8.4.1 If removable contamination is suspected or previous surveys are in question, first scan likely contaminated areas with an α and/or β probe to 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 are found, use appropriate protective clothing and entry control techniques to prevent the spread of contamination.

8.4.2 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.

8.4.2.1 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 OP-001-02 or equivalent form.

8.4.2.2 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 OP-001-02 or equivalent form. 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 OP-001-02 or equivalent survey form.

8.4.2.3 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.

8.4.2.4 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 OP-001-02 or equivalent form. DOT regulations may require additional survey points.

8.4.2.5 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 Large Area Smears (LAS). Use Masslin cloth or equivalent material to obtain a large area smear 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 OP-001-02 or equivalent form. DOT regulations may require additional survey points.

NOTE: The presence of activity above transferable limits on an LAS signifies potential contamination. Determine actions to be taken with the RSO or RFS.

8.4.3 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.

8.4.3.1 The grid system established in section 8.3.3.1 will also be utilized for contamination surveys.

8.4.3.2 Hold the beta probe at approximately ½ inch above the grid center point and obtain reading following meter stabilization. Record the meter reading on OP-001-02 or equivalent form.

8.4.3.3 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 OP-001-02 or equivalent form.

8.4.3.4 If readings are at or near the release levels, scan grid surface and identify 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 OP-001-02 or equivalent form.

Repeat steps 8.4.3.2 through 8.4.3.4 with an alpha probe at ¼ inch above the grid center point. If sufficient documentation of previous history is known about the facility, the alpha survey may not be required if alpha contamination is known not to be present.

8.4.3.5 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.

8.4.3.6 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 OP-001-02 or equivalent Form.

8.4.4 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.

8.4.4.1 The grid system established in section 8.3.4, will be utilized for contamination surveys.

8.4.4.2 Hold the beta probe at ½ inch above the grid center point and obtain reading following meter stabilization. Record the meter reading on OP-001-02 or equivalent form.

8.4.4.3 If readings are at background levels, randomly scan the remainder of the grid. Mark any locations above release criteria on OP-001-02 or equivalent form.

8.4.4.4 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 OP-001-02 or equivalent form.

8.4.4.5 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.

8.5 Frequency and Requirements for Routine Surveys

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

8.5.1 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 HEPA-filtered ventilation units
- Weekly, for any temporary Radiation Area boundaries to ensure that the Radiation Areas do not extend beyond posted boundaries
- Monthly, or upon entry if entries are less than monthly, for Radioactive Material Storage Areas

8.5.2 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
- Weekly for all project offices on site

8.5.3 Airborne Surveys:

Airborne survey frequency, locations, and methods are determined by the radiation work permits (RWP's) and by the RSO.

8.6 Identifying and Scheduling Routine Radiological Surveys

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

8.6.2 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

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

8.6.4 Routine Survey Schedules should be indicated on form OP-001-01 or equivalent. Task Leaders may elect alternate methods of determining the information contained on OP-001-01.

8.7 Using As Low As is Reasonably Achievable (ALARA) Principles for Scheduling and Performing Surveys

8.7.1 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.

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

8.8 Performance of Routine Surveys

8.8.1 HPT's and qualified individuals shall perform routine surveys in accordance with the applicable operational procedure.

8.8.2 Upon completion of a routine survey, the HPT shall initial and date the appropriate Survey Form.

8.9 Periodic Evaluation of Routine Surveys

8.9.1 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.

8.9.2 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.

8.10 Management Notification

8.10.1 The RSO should be notified, by the project manager 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.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 Instruments used to perform routine radiological surveys will be inspected for serviceability each day and checked against check sources to verify they are in proper working condition per the applicable Operational Procedure and standard work practices.

9.1.2 Radiation and Contamination surveys will be reviewed by the RSO or duly authorized representative for accuracy and completeness.

9.2 Records

9.2.1 At a minimum, each survey record should include the following:

- 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.

9.2.2 Radiological Survey Records, routine survey schedules, and tracking forms are generated during the performance of this procedure. Electronic equivalents of forms may be utilized.

9.2.3 Documented information shall be legibly written in ink.

9.2.4 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.

9.2.5 Personnel performing the survey shall ensure that this procedure is the most current and approved revision.

9.2.6 Personnel performing the survey shall review forms and any other electronic equivalents for accuracy and completeness.

9.2.7 Entries on forms and any other pertinent forms must be dated and initialed by the individual performing the survey to be valid.

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

10.0 ATTACHMENTS

- OP-001-01 Routine Survey Schedule
- OP-001-02 Survey Form

OP-001-01
ROUTINE SURVEY SCHEDULE

Survey Designation	Location of Survey

Prepared By: _____ Date: _____

Reviewed By: _____ Date: _____

OP-001-02 Radiological Survey Sheet

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

Smear Results CPM/100cm^2					
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:

Reviewed By: Date:

Instrument	Serial #	α Eff.	β Eff.	α Bkg.	β Bkg	Cal. Due

Key			
⬭	Smear	*-*	Boundary
▭	Dose Rate mrem/hr ■		A/S Location
*	Direct Reading CPM/100 cm^2		
△	Grab Sample		

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Air Sampling and Analysis

OP-002

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 provides the methods Cabrera Services, Inc. (CABRERA) uses in operation of air samplers and calculation of radioactive particulate activity in air sample. This procedure describes the methods used to calculate Derived Air Concentration (DAC) DAC-hour exposures to workers. Adherence to this procedure will provide 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, calculate, and record DAC-Hour exposures to workers. Air samples are performed when the average alpha and beta contamination on facility surfaces, equipment and waste packages exceed the contamination limits specified in Table 1 of the Radiation Protection Manual (RPM) and included as Attachment OP-002-03 of this procedure. Air monitoring shall be performed in areas where there exists potential to exceed 10 percent of any DAC.

3.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

3.1 Precautions

Not Applicable

3.2 Limitations

Not Applicable

3.3 Requirements

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

3.3.2 Air sampler inspections shall be performed by qualified Health Physics personnel.

4.0 REFERENCES

- RSP Radiation Safety Program
- AP-001 Record Retention
- OP-021 Alpha-Beta Sample Counting Instrumentation
- Reg Guide 8.25 Air sampling in the Workplace
- NUREG-1556 Consolidated Guidance About Material Licenses (Vol.11)

5.0 DEFINITIONS AND ABBREVIATIONS

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

5.2 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.

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

5.4 Annual Limit on Intake (ALI) – The annual limit on intake (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 week for 50 weeks) that would result in a committed effective dose equivalent (CEDE) of 5 rem or a committed dose equivalent (CDE) of 50 rems to any individual organ or tissue.

5.5 Derived Air Concentration (DAC) – Derived air concentration 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.

5.6 DAC-Hour – The product of the concentration of radioactive material in air (expressed as a multiple of the derived air concentration for each nuclide) and the time of exposure to that nuclide, in hours, 2000 DAC-Hours represents one ALI.

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

5.7.1 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, or

5.7.2 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 on the annual limit on intake (ALI) or 12 DAC-hrs.

6.0 EQUIPMENT

6.1 None

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – the PM is responsible for ensuring that personnel assigned the task of air sampling and air sampling analysis are familiar with this procedure, adequately trained with the specific instrument being used to perform surveys.

7.2 Radiation Safety Officer (RSO) – The RSO is responsible for monitoring compliance with this procedure and training personnel in the use of the air sampling and air sampling analysis. 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 performing air sampling and air sampling analysis are responsible for knowing and complying with this procedure.

8.0 INSTRUCTIONS

8.1 Initial Preparation

8.1.1 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 radiation safety officer for special sampling procedures before proceeding.

8.1.1.1 Area air samples are normally collected with a low volume air sampler having normal airflow of 1 CFM to 5 CFM.

8.1.1.2 Breathing zone air samples are normally collected using lapel air samplers, which have a normal airflow of 1 to 5 liters per minute.

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

8.1.2 Attach the air sampling head to the intake of the low volume sample pump or to the tygon tubing of the Lapel sampler.

8.1.3 Obtain the filter paper to be used in the sample and mark the backside of the filter with a unique number, which will represent the sample. During the collection and handling of air sample filter papers, caution must be used to prevent the samples from being contaminated by other radioactive materials.

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

8.1.4.1 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 “down wind” of the area where workers will be resuspending radioactive particulates into the workers atmosphere.

8.1.4.2 Lapel air samples are collected from workers breathing zone. The sample head is attached to the shoulder of the worker with the sample head facing forward. 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.

8.2 Collecting the sample

8.2.1 When the sample head is in position, start the sample pump and adjust the flow rate to the highest flow rate, which can be maintained without flow rate fluctuations.

8.2.2 Record the time the sample was started and the initial flow rate of the sample pump on Form OP-002-01, Air Sample Data Sheet.

8.2.3 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.

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

8.2.5 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.

CAUTION: Be sure not to remove activity from the sample surface. Handle the filter with care.

8.2.6 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.

8.2.7 Record the names of workers who were in the area and the time spent in the work area on the Air Sample Data sheet.

8.2.8 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.

8.2.9 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.

8.3 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.

8.3.1 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

$2.22X10^6$ = Disintergrations per minute per microCurie (DPM/uCi)

k_α = 1.645 for a confidence level of 95% and 1.96 for a confidence level of 99%

8.3.2 If the MDA is larger than 10% of the Derived Air Concentration, 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.

8.4 Initial Air Sample Analysis – The initial analysis of air sample 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 samples should be available before work resumes the following day.

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

8.4.2 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).

8.4.3 Record the Alpha and Beta sample DPM results in the Air Sample Data sheet.

8.4.4 Calculate the alpha and beta air concentrations using the following formula. Adjustment due to alpha self absorption are made as appropriate.

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

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

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

8.4.6 If the air concentration is less than 10 percent 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 8.5.

8.5 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.

8.5.1 Air particulate samples are analyzed following 12 hour decay, and again at 72 hours if necessary to allow for decay of radon, for gross alpha and gross beta using a Ludlum Model 2929 Dual Channel Scaler or equivalent.

8.5.2 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).

8.5.3 Record the Alpha and Beta sample DPM results in the Air Sample Data sheet.

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

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

8.5.5 Enter the alpha and beta air concentrations on the Air Sample Data sheet in the space provided for the 12-hour decay concentrations. If the 12-hour decay air concentrations is below 10% of the DAC no further analysis is required.

8.5.6 If the 12-hour air concentration is above 10% percent of the DAC value, recount the air sample following 72 hours of decay from the time the sample was stopped. Calculate the air concentration using the formula in step 8.5.4 and record the air concentrations in the space provided for the 72-hour decay air concentration on the Air Sample Data sheet. If the 72-hour air concentration is below 10% of the DAC value, no further analysis is required.

8.5.7 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.

8.6 Assignment of DAC-Hour exposures to workers

8.6.1 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 uCi/cm^3

B = Hours worker was in the calculated air concentration

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

8.6.2 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.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

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

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 air sampling and analysis shall ensure that this procedure is the most current and approved revision.

9.2.4 The health physics technician performing air sampling and analysis shall review all applicable forms for accuracy and completeness.

9.2.5 Entries on and any other pertinent forms must be dated and initialed by the health physics technician performing the air sampling and analysis 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

OP-002-01	Air Sample Data Sheet
OP-002-02	Daily Air Sample Record
OP-002-03	Contamination Limits

OP-002-01

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

Initial Air Concentration:

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

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

12 Hour Decay Air Concentration:

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

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

72 Hour Decay Concentration:

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

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

Performed By: _____ Date: _____

OP-002-02

Daily Air Sample Record

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

OP-002-03

Contamination Limits from Table 1 of RPM

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 · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Use and Control of Radioactive
Check Sources

OP-009

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 methods for control of instrument check sources and the methods used to evaluate sources for the potential of leaking radioactive material. These sources are used to ensure proper radiation detection instrument operation. 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, adherence to this procedure will provide reasonable assurance that leak testing of radioactive sources meet the requirements of 10 CFR 20 and NRC license.

2.0 APPLICABILITY

This procedure will be used by Cabrera Services, Inc. (CABRERA) personnel for use and control of radioactive check sources used for portable radiation detectors. This procedure will also be used for leak testing of radioactive sources and also applies to licensed and exempt sources.

3.0 PRECAUTIONS, LIMITATIONS, AND REQUIREMENTS

3.1 Precautions

3.1.1 When performing a leak test on non-exempt quantity sources, use specific license procedures.

3.1.2 If non-exempt quantity sources are used, the RSO or duly authorized representative will determine any additional precautions (i.e., finger rings, etc.).

3.1.3 If licensed quantity sources are leak tested, the RSO or duly authorized representative will determine any additional precautions (i.e., finger rings, etc.).

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

3.1.5 The window area of a particle detector is 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, monitor the sample away from the source. If the sample yields a high-count rate compared to

background, assume the source to be leaking and estimate the activity based upon the reading of the portable instrument.

3.2 Limitations

3.2.1 Storage location(s) of instrument check 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.

3.2.2 A Radiation Work Permit must be generated for leak testing of non-exempt sources.

3.3 Requirements

3.3.1 Individual source quantities shall not exceed exempt quantity limits without permission of the RSO or duly authorized representative.

3.3.2 The methods specified in this procedure will be audited annually to ensure compliance with the requirements to control radioactive sources.

3.3.3 The results of leak test samples shall be less than 0.005 microcuries of removable activity in order to comply with NRC requirements.

3.3.4 Ensure accountability and direct control of the source at all times when it is unlocked. 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.

3.3.5 Only qualified Health Physics personnel may use or have possession of CABRERA radioactive check sources.

4.0 REFERENCES

- AP-001 Record Retention
- RSP Radiation Safety Program
- OP-001 Radiological Surveys
- OP-020 Operation of Contamination Survey Meters
- OP-021 Alpha-Beta Sample Counting Instrumentation
- OP-022 Operation of Ionization Chambers
- OP-023 Operation of Micro-R Survey Meters
- NUREG-1556 Consolidated Guidance About Material Licenses (Vol.11)

5.0 DEFINITIONS AND ABBREVIATIONS

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

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

6.0 EQUIPMENT

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

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – The PM is responsible for ensuring that all personnel assigned the tasks of control and leak testing of sealed sources 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 verifying that personnel comply with this procedure and are trained with radioactive sources as described in this procedure. The RSO ensures the Health Physics Technicians 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 and use of radioactive check sources. The HPT conducting leak tests of sealed sources are responsible to comply with the provisions of this procedure.

8.0 INSTRUCTIONS

8.1 Action Levels

- Inventory

  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.

- Leakage

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

- Radiation Levels

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

8.2 Inventory

A physical inventory of all instrument check sources will be conducted by the RSO or duly authorized representative at least once each quarter and whenever a new check source is received or an old check source is disposed. The results shall be recorded on Form OP-009-01 and shall be retained in the source file for a period of not less than three years.

8.3 Initial Preparations

8.3.1 Select a work area to conduct the leak test that is free of radioactive contamination.

8.3.2 Select instruments that are capable of detecting at least 0.005 microcuries of the radionuclide of concern.

8.3.3 Prepare distilled water in a nearby container, as appropriate, for the equipment being tested. Specific solutions may be mentioned in vendor documentation. If they are, use the solutions required by the vendor.

8.3.4 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 provide precautionary measures to ensure protection of people and equipment in the work area.

Caution: Do not touch or get close to an exposed source of high activity. Sealed sources of high activity may cause extremely high dose rates, which may result in physical damage to your body.

8.3.5 Using remote means, smear the outside surface of the source using cloth or paper. This smear will be the leak test sample that is analyzed for activity associated with a potentially leaking source.

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

8.3.7 Minimize the time period for conducting the leak test. In a well planned test, the time should be less than 10 seconds total.

8.3.8 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.

8.3.9 Be sure to wear rubber or latex gloves when handling the leak test samples or equipment associated with the test.

8.4 Monitoring Technique

8.4.1 To maintain the calibrated detection efficiency, the detector must be held at the appropriate height, determined during calibration, when surveying. For example, if beta probe's efficiency was calculated at 1/2 inch from the calibration source, the detector must be held at 1/2 inch from the surface being surveyed to maintain calibrated detection efficiency.

8.5 Analysis

The leak test sample shall be analyzed by a method, which will ensure detection of at least 0.005 microcuries of the radionuclide of interest. Existing CABRERA procedures 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.

8.6 Performing a Leak Test

8.6.1 Although leak tests are not required for exempt quantity sealed sources, in the event a source is suspected of having a loss of

encapsulation or other possible leakage, the following procedure shall be followed, under the direction of the RSO or duly authorized representative :

8.6.1.1 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, otherwise proceed to step 8.3.1.2.

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

CAUTION: High activity sources may have very high exposure rates on contact. Sources containing activity in excess of the exempt limits shall handled by remote means to ensure exposure is maintained As Low As Reasonably Achievable.

8.6.1.3 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. 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.

8.6.1.4 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 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.

8.6.2 When any contamination or leak test reveals the presence of 0.005 μCi or greater of removable contamination, or activity removed is above the critical level of the detecting instrument, 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 Form OP-009-02 and shall be retained for a minimum of three years.

8.7 Survey

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

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 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.

9.2 Records

9.2.1 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 "Sealed Source Inventory and Leak Test" Form ; and,
- Any other correspondence related to the sources.

9.2.2 Documented information shall be legibly written in ink.

9.2.3 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.

9.2.4 The health physics technician using this procedure shall ensure that it is the most current and approved revision.

9.2.5 The health physics technician performing inventory shall review Forms OP-009-01 and OP-009-02 for accuracy and completeness.

9.2.6 Entries on Forms OP-009-01 and OP-009-02 and any other pertinent forms must be dated and initialed by the health physics technician performing the inventory to be valid.

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

10.0 ATTACHMENTS

OP-009-01 Sealed Source Inventory and Leak Test

OP-009-02 Sealed Source Leak Test Data Sheet

OP-009-01
SEALED SOURCE INVENTORY AND LEAK TEST

Inventory Period: First Quarter ☐ Second Quarter ☐ Third Quarter ☐ Fourth Quarter ☐

Isotope	Source (Type/Form)	Serial Number	Location	Initial Activity	Corrected Activity	Leak Test uCi/smear

Comments_____
_____
_____

Date Performed:_____ By:_____
Print/Sign

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

OP-009-02
Sealed 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:_____Ci Source Today: _____ Ci

Radionuclide name: _____ Half-life of radionuclide_____

Leak Test Sample Information

Location of Leak Test Work Area _____

Describe the method of leak testing:_____

_____

Sample Geometry: _____ Detector: _____

Detection Efficiency:_____c/d Background count time: _____ min.

Background count rate: _____cpm MDA: _____ microcuries

Sample net count rate: _____cpm Sample count time: _____ min.

Leak test sample activity: _____ microcuries

Leak Test Result – Check all boxes that apply

- ❑ The leak test sample is in excess of the 0.005 microcurie limit
- ❑ The leak test sample is below the 0.005 microcurie limit
- ❑ The source has been controlled to prevent the spread of activity from the shield.

Source Leak Test Performed by:_____ Date: _____

Leak Test Analysis Conducted by: _____ Date: _____

Radiation Safety Officer: _____ Date: _____

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Decontamination of Equipment and Tools

OP-018

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 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 procedure will be used to identify proper decontamination methods, provide instruction for the decontamination of equipment, material, and tools. Each decontamination operation is unique; thus, this procedure provides general, effective domination techniques and guidelines to be use by CABRERA field personnel. This document applies to all CABRERA PERSONNEL involved in the decontamination process.

3.0 PRECAUTIONS, LIMITATIONS AND REQUIREMENTS

3.1 Precautions

3.1.1 Decontamination of contaminated tools or equipment shall be performed under the direction of a HPT. The HPT shall provide direction in accordance with this procedure, and the Radiation Work Permit (RWP).

3.1.2 Decontamination activities shall be performed within a controlled area established in accordance with the provisions of procedure OP-019.

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

3.2 Limitations

3.2.1 Protective clothing worn by the personnel involved in decontamination activities shall be determined in accordance with the RWP.

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

3.2.3 Respiratory protection devices required by the RWP for decontamination operations shall be selected and used in accordance with the provisions of AP-006.

3.2.4 A pre-job briefing shall be held to instruct Decontamination Technicians of the conditions of the RWP. All personnel performing work in the decontamination work area shall sign the RWP prior to work.

3.2.5 Every effort should be made by CABRERA personnel to avoid re-contamination of decontaminated materials. Contamination controls shall always be observed throughout a decontamination process.

3.2.6 Radiation and contamination surveys shall be performed in accordance with the provisions of procedure OP-001.

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

3.3 Requirements

None

4.0 REFERENCES

- RSP Radiation Safety Program
- AP-001 Records Retention
- AP-006 Respiratory Protection Program
- AP-012 Radiation Work Permits
- AP-013 Packaging Radioactive Material
- AP-014 Classifying Radioactive Waste
- OP-001 Radiological Surveys
- OP-004 Unconditional Release of Material from Radiological Control Areas
- OP-019 Radiological Posting
- OP-020 Operation of Contamination Survey Meters
- OP-021 Operation of Alpha-Beta Sample Counting Instrumentation
- OP-023 Operation of Micro-R Survey Meters

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Decontamination - The processes whereby contamination can be safely and effectively removed from equipment, tools and materials, to levels required by Reg. Guide 1.86.

5.2 Herculite - A plastic or polyethylene floor covering and containment material use for decontamination operations. HERCULITE is a brand name.

5.3 MSDS - Material Safety Data Sheet provide safety information and limitations and are issued by the manufacturer of the product.

5.4 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).
- Period of time the RWP is valid.
- Special instructions to workers and HP personnel for the work.

6.0 EQUIPMENT

None

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – The PM is responsible for ensuring that personnel assigned the task of decontamination 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 is responsible for training of personnel in decontamination techniques and performing radiation surveys described in this procedure. The RSO ensures that decontamination technicians 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 performing the surveys of decontaminated items, and ensuring that radioactive material is not released to the public or the environment.

8.0 INSTRUCTIONS

8.1 Pre-Decontamination Preparation

8.1.1 The RFS shall initiate decontamination work instructions.

8.1.2 A radiological survey shall be performed by a HPT on any item or object, which is to be removed from a controlled area.

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

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

8.1.5 The RFS shall approve or disapprove the decontamination operation based on conditions of the RWP and the cost effectiveness of the operation versus disposal costs.

8.2 Establishment of the Decontamination Work Area

8.2.1 The RSO or duly authorized representative and the RFS shall determine a location for decontamination area.

8.2.2 Once a location has been established, the decontamination area shall be set-up by the HPT under the direction of the RFS.

8.2.3 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.

- Covered (Herculite or equivalent) wall surfaces, if applicable.

- Engineering controls (HEPA ventilation, vacuum cleaners, containment tent walls glove bags, etc.), if applicable.

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

NOTE: All possible engineering controls shall be utilizes when feasible to minimize the need for respiratory protection equipment.

- Safe, sturdy workstations with contamination resistant surfaces. 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.

- Overhead lifting equipment, if applicable.

- Adequate supply of CABRERA approved cleaning solutions and solvents; adequate supply of decontamination equipment such as:

1. Light duty decontamination equipment such as paper wipes, paper towels, massllin towels, etc.

2. Medium to Heavy-duty decontamination equipment such as scrub pads, wire brushes steel wool, files, sandpaper, etc.

3. Fully stocked hand tool kit for disassemble of contaminated equipment.

4. Power tools, such as drills, saws, electric screwdrivers, etc.

5. Radioactive material storage bags, stickers, etc.

6. Buckets, barrels or drums for the storage of contaminated liquids, sludges, or slurries, if applicable.

7. Blotter paper or sorbent, if applicable.

8. Approved absorbent material such as oil dry, etc., if applicable.

- Storage drums/bags for the storage of contaminated protective clothing under direction of Health Physics.

- 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.

- Fire extinguisher(s), if required

8.2.4 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 decontamination technician under the direction of the RFS and the HPT. Contaminated or controlled items should always be escorted under the direction of a HPT to the decontamination area.

8.3 Decontamination

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

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

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

NOTE: Junior Health Physics/Decontamination Technicians may operate survey instruments for decontamination monitoring purpose. HPTs shall oversee Junior Health Physics/Decontamination Technicians 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 HPTs shall 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 smearable 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.

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

- Any equipment with inaccessible areas shall be dismantled so that all surfaces are accessible for decontamination and for survey.

- Decontamination shall be performed in a safe, effective manner.

- The HPT shall 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 HPT (or qualified individual) shall 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 shall be a dedicated fire extinguisher located within the decontamination work area.

- In order to secure a safe cleaning surface, the item should be positioned on the worktable (if size and weight permits) and locked into a vise or secured by other approved methods as determined by the RFS.

- The decontamination area shall remain organized and free of debris. The HPT shall enforce the "clean-as-you-go" policy whenever necessary.

- A HEPA vacuum cleaner may be used during the decontamination operation.

8.3.4 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 approve liquid (e.g. demineralized water).

- Fold a paper or cloth wipe into sections, using one surface of the wipe gently and 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. Adhesive side out. Roll the tape over the contaminated area. Re-survey.

8.3.5 Fixed Contamination Removal

There are many techniques that can be use 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 RFS and the HPT. 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.

8.3.6 Light hand decontamination consists of using many of the same techniques as 8.3.4 of this procedure.

8.3.7 Abrasive hand decontamination shall 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, which 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.

8.3.8 Power tool decontamination shall be performed in the following manner only under the direction of the HPT.

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

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

  - Drills - used 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 - used to separate contaminated pieces from clean pieces.

  - Grinders - used to grind fixed contamination form surfaces.

  - Electric screwdrivers - used in the disassembly of component parts

8.3.9 Power tool decontamination shall be performed in the following manner:

- Remove as much smearable contamination as possible as per Section 8.3.4 of this procedure.

- Moisten the surface of the item lightly to contain contamination. Use a spray bottle for moistening.

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

- Whenever feasible the use of containment device (e.g. glove box, 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.

8.4 Post Decontamination

8.4.1 If the decontamination was successful, the decontamination technician shall notify the HPT who shall perform a release survey in accordance with OP-004.

- If the item satisfies the criteria for release as 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 AP-014 and AP-013.

- If the item remains contaminated, attempt a second decontamination.
- If the item remains contaminated, attempt a third decontamination only at the direction of the RSO or duly authorized representative.

8.4.2 If an item cannot be effectively or economically decontaminated, the RFS 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 8.4.1.

8.4.3 If an item is volume-reduced to its component parts and decontamination is not feasible, and the item is not needed, the item parts shall be considered radioactive waste. Radioactive waste is to be segregated into similar material for shipment purposes by the direction of the Project Manager. The RFS shall 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.

8.4.4 After all decontamination operation have been completed a HPT shall perform a release survey of the decontamination area and de-post the area in accordance with procedures OP-001 and OP-019.

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

9.2 Records

9.2.1 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.

9.2.2 Documented information shall be legible written in ink.

9.2.3 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.

10.0 ATTACHMENTS

None

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Alpha – Beta Counting Instrumentation

OP-021

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 provides instruction on the operation and setup of an alpha/beta sample counter. Adherence to this procedure will provide 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, and source packages, etc.

- Air sample surveys performed in a workers breathing zone to determine alpha and beta air concentrations.

3.0 PRECAUTIONS, LIMITATIONS, AND REQUIREMENTS

3.1 Precautions

3.1.1 If any instrument inconsistencies are observed (e.g., unusually high or low background counts, source checks outside the tolerance range, etc.), remove the instrument from use and report the condition to the RSO or duly authorized representative.

3.1.2 Individuals performing work with an alpha/beta counter shall be familiar with the requirements set forth in the current and approved version of this procedure.

3.2 Limitations

3.2.1 This instrument should be set up for use in low background area as determined by the RSO or duly authorized representative.

3.3 Requirements

3.3.1 Calibration sources shall be traceable to the National Institutes of Science and Technology (NIST).

3.3.2 Survey instrument calibrations shall be performed by an NRC or Agreement State licensed calibration facility.

3.3.3 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.

4.0 REFERENCES

- RSP Radiation Safety Program
- AP-005 ALARA Program
- AP-001 Record Retention
- AP-013 Packaging Radioactive Material
- OP-001 Radiological Surveys
- 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 Smear sample survey – a technique using a two-inch diameter filter papers to determine removable contamination of alpha and/or beta emitting radioactive material.

5.3 Air sample survey – a technique in which particulates are collected from a known volume of air drawn through a filter paper and concentrations of airborne alpha and beta activity associated with the particulates is determined by sample counting.

5.4 Plateau – portion of a voltage curve where changes in operating voltage introduce minimum changes in the counting rate.

5.5 Chi-square test – A statistical test to evaluate the operation of a sample counter by determining how data fit a series of counts to a Poisson distribution.

5.6 Daily calibration – A determination of alpha and beta sample counting efficiency by counting National Institute of Standard Technologies (NIST) radioactive standards.

6.0 EQUIPMENT

Ludlum model 2929 or equivalent

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – the PM is responsible for ensuring that personnel assigned the task of operating alpha/beta sample counters 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 verifying that personnel comply with this procedure and are trained in the use of alpha/beta sample counters 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 using alpha/beta sample counters 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.

8.1.2 Remove and tag the instrument "Out of Service" if it fails any of the criteria in Step 8.1.1.1 through 8.1.1.2 and notify the RSO or his duly authorized representative.

NOTE: Any defects, damages or other physical abnormalities require that the instrument be removed from service and the RSO or his duly authorized representative be notified.

8.2 Initial Startup.

8.2.1 Turn high voltage potentiometer to its lowest position (fully counterclockwise).

8.2.2 Turn instrument on.

8.2.3 The operator can select one of four operational procedures depending on the function to be performed. Before performing any of the following complete steps 8.1.1 to 8.1.2.

a) Plateau Curve – The Plateau Curve is used to find the proper operating voltage of the instrument and will be performed at the discretion of the RSO or duly authorized representative. This test shall be documented on the attached Form OP-021-01 or equivalent.

b) Chi–square Test – The Chi-Square Test will be performed at the discretion of the RSO or duly authorized representative in order to test the operational adequacy of the instrument and will be recorded on Form OP-021-02. This test statistically evaluates the sample counter against a poisson distribution.

c) Daily Calibration Check – This portion of the procedure is performed before samples are counted on any day the instrument is in use.

8.3 Plateau Curve

NOTE: Before beginning, record the previous calibration high voltage values.

8.3.1 Set up the instrument in a low background area.

8.3.2 Rotate the high voltage potentiometer slowly clockwise until the meter indicates proper voltage. This proper voltage is approximately 500 volts.

8.3.3 Set time multiplier switch to “x1.”

8.3.4 Set the instrument-preset timer to one (1) minute.

8.3.5 Insert an alpha calibration standard into the center of the sample tray, slide the sample tray under the detector and depress the “COUNT” button to obtain a one minute count.

8.3.6 Upon completion of the count, record high voltage reading and digital counts appearing in the instrument alpha display in the indicated columns on Form OP-021-01(Plateau Data Sheet)

8.3.7 Continue increasing high voltage by 50-volt increments, as described above, obtaining counts and recording data until the end of the plateau is reached. If rapid increase in count rate is observed, proceed to step 8.3.8. If not, notify the RSO or duly authorized representative.

8.3.8 Remove the alpha source and replace with a beta source.

8.3.9 Reduce high voltage reading to the voltage level chosen during Step 8.3.2 by turning potentiometer counterclockwise.

8.3.10 Perform one-minute counts at 50-volt increments and record the data on Form OP-020-01, until the end of the plateau is reached. If a rapid increase in count rate is observed reduce the high voltage.

8.3.11 Using linear graph paper or equivalent plotting system, plot alpha and beta counts on the "Y" axis and the voltage for the indicated count on the "X" axis.

8.3.12 Select an operating voltage 1/3 the distance beyond the knee of the plateau curve by marking the voltage on the graph and on the plateau data sheet.

8.3.13 Sign and date Form OP-021-01 and forward the results along with any graphs produced to the RSO or duly authorized representative for review.

8.4 Chi-Square Test

8.4.1 Set up the Instrument in a low background area.

8.4.2 Ensure the high voltage potentiometer is positioned according to the posted instrument label. Adjust if necessary.

8.4.3 Set the time multiplier switch to "x1".

8.4.4 Set the instrument-preset timer to one (1) minute.

8.4.5 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.

8.4.6 Upon completion of the count, record digital counts appearing in the alpha display in the "X_i" column on Form OP-021-02 (Chi -Square Data Sheet).

8.4.7 Repeat counting sequence without changing settings until a total of 20 counts have been taken and recorded in the "X_i" column on Form OP-021-02.

8.4.8 Add the 20 counts recorded in the "X_i" column and record in the "Sum" column. Then divide by 20 to obtain the mean number of counts (X_m) and record on the line "X_m".

8.4.9 Calculate the individual count "X_i" difference from the mean (X_m) value and record in the "(X_i-X_m)" column on Form OP-021-02 for all 20 values.

8.4.10 Calculate $(X_i-X_m)^2$, sum the "$(X_i-X_m)^2$ " column, and record on Form OP-020-02.

8.4.11 Calculate the value of Chi- Square using the following formula.

$$X^2 = \frac{\sum (X_i - X_m)^2}{X_m}$$

8.4.12 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 "X^2". If the Chi-square value falls outside this range, contact the RSO or duly authorized representative for further instructions.

8.4.13 Sign and date Form OP-021-02 and forward the results to the RSO or duly authorized representative for review.

8.5 Daily Calibration Check

8.5.1 Ensure the high voltage potentiometer is positioned according to the posted instrument label. Adjust, slowly, if necessary.

8.5.2 Set time multiplier switch to "x1".

8.5.3 Set the instrument-preset timer to five (5) minutes.

8.5.4 Record the source type to be used and corresponding serial number on the proper line indicated on Form OP-021-03. Use separate rows of the form for each source efficiency to be calculated.

8.5.5 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 five minute background count.

8.5.6 Calculate and record the background total counts and count rate in the columns labeled "Total Counts" and "BKG CPM" respectively, under Background Information on Form OP-021-03. The background count rate in CPM (counts per minute) can be calculated as follows:

$$CPM = \frac{\text{Total Counts}}{\text{Total Time}}$$

8.5.7 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 five minute count.

8.5.8 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 Form OP-021-03. The count rate (CPM) can be calculated as listed in Step 8.5.6.

8.5.9 Calculate Net Source CPM as below and record on Form OP-021-03 under “Net CPM”.

Net Source CPM = CPM – BKG CPM

NOTE: Obtain activity (DPM) value from the source certification paperwork. Decay correct activity, if needed.

8.5.10 Use the source disintegration per minute (DPM) to calculate the efficiency as shown below and record as a decimal on Form OP-021-03.

$$\%\ Efficiency = \frac{Net\ Source\ CPM}{DPM} * 100$$

8.5.11 To calculate the efficiency for the next source, remove the current source standard, insert a new source standard and repeat steps 8.5.1 through 8.5.10, as necessary.

8.5.12 Remove calibration standards and place in source holders.

8.5.13 Generate a control chart tracking the daily efficiencies and notify the RSO or duly authorized representative if any point falls outside of 2σ variance.

NOTE: For the first day on control chart use five data points to begin trend line.

9.0 QUALITY ASSURANCE/RECORDS

9.1 Quality Assurance

9.1.1 The alpha/beta sample counter will be checked for proper calibration daily with a NIST traceable source when in use.

9.1.2 Chi-square and plateau tests are verified and noted as currently valid.

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

9.2 Records

9.2.1 Documented information shall be legible 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 review completed attachment forms for accuracy and completeness.

9.2.4 Entries on forms must be dated and initialed by the HPT 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

- OP-021-01 Plateau Data Sheet
- OP-021-02 Chi–Square Data Sheet
- OP-021-03 Daily Calibration Check

OP-021-01

Plateau Data Sheet

Date:_____ Recommended Operating Voltage:_____

Instrument:_____ Serial Number:_____

Alpha Source Serial No._____ Activity (dpm)_____

Beta Source Serial No._____ Activity (dpm)_____

Voltage Setting	Alpha Counts	Voltage Setting	Alpha Counts	Voltage Setting	Beta Counts	Voltage Setting	Beta Counts

Prepared By:_____ Date:_____
Print/Sign

Reviewed By:_____ Date:_____
Print/Sign

OP-021-02

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

OP-021-03

Daily Calibration Check

Instrument_____ Serial No._____

Alpha Source No./Activity_____ Beta Source No./Activity_____

Background Information				Source Information				
Date/Time	**Total Time**	**Total Counts**	**BKG CPM**	**Total Time**	**Total Counts**	**CPM**	**Net CPM**	**% Eff.**

Prepared By: _____ Date: _____
Print/Sign

Reviewed By: _____ Date: _____
Print/Sign

CABRERA SERVICES

RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

Radiation Safety Procedure

For

Operation of Contamination Survey Meters

OP-020

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 provides the methods for operating alpha/beta survey meters when performing contamination surveys. Adherence to this procedure will provide reasonable assurance that the surveys performed have reproducible results.

2.0 APPLICABILTY

This procedure will be used by Cabrera Services, Inc. (CABRERA) personnel to measure fixed and removable alpha and/or beta emitting radioactive material on facility surfaces, equipment, waste packages, personnel, personnel protective clothing, etc.

3.0 PRECAUTIONS, LIMITATIONS, AND REQUIREMENTS

3.1 Precautions

3.1.1 Ensure that the thin Mylar or mica window on the probe face is protected from punctures during survey operations.

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
- AP-001 Record Retention
- OP-001 Radiological Surveys
- OP-009 Use and Control of Radioactive Check Sources

5.0 DEFINITIONS AND ABBREVIATIONS

5.1 Restricted Area - An area containing radioactive material(s) to which access is controlled to protect individuals from exposure to ionizing radiation.

5.2 Alpha/Beta Contamination Survey - A survey technique to determine fixed and removable alpha/beta contamination.

5.3 Acceptance Range - A range of values that describe an acceptable daily instrument source check result.

6.0 EQUIPMENT

6.1 For Alpha Surveys Ludlum Model 43-5 probe and Ludlum Model 3 survey meter or equivalent meter/probe combination.

6.2 For Beta Surveys Ludlum Model 44-9 probe and Ludlum Model 3 survey meter or equivalent meter/probe combination.

7.0 RESPONSIBILITIES

7.1 Project Manager (PM) – the PM is responsible for ensuring that personnel assigned the task of operating contamination survey meters 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 verifying that personnel comply with this procedure and are trained in the use of contamination survey meters 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 contamination survey meters are responsible for knowing and complying with this procedure.

8.0 OPERATION

8.1 Instrument Inspection

8.1.1 Select the contamination survey meter and probe to be used in the survey.

8.1.2 Before each use, perform the following checks:

8.1.2.1 Verify the instrument has a current calibration label.

8.1.2.2 Visually inspect the instrument for physical damage or defects.

8.1.2.3 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.

8.1.2.4 Check alpha detectors for light leaks by pointing the mylar window of the detector toward a light source and observing no change in the meter indication.

8.1.3 Remove and tag the instrument "Out of Service" if it fails any of the criteria in Step 8.1.2.1 through 8.1.2.44 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 Obtain an OP-020-01 Form.

8.2.4 If a Quality Control (Q.C.) acceptance range has not already been calculated on the OP-020-01 Form, then follow the instructions below, other wise proceed to step 8.2.5.

8.2.4.1 Ensure the source and detector are in documented reproducible positions, which will be used each time this check is performed. Document this position on Form OP-020-01.

8.2.5 Place the QC check source and detector in the documented position on Form OP-020-01.

8.2.6 Allow the instrument reading to stabilize (approximately 30 seconds). Compare the reading to the response check criteria on Form OP-020-01. 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 Contamination Survey Techniques

Caution: The window area of alpha detectors are covered with a very thin (1 mg/cm^2) aluminized Mylar window and beta detector windows are 1.7 mg/cm^2 mica. Either window can be easily when surveying areas, which have protruding fragments that might puncture the detector face. Remove these fragments before performing surveys.

Note: To maintain the calibrated detection efficiency, the detector must be held at the appropriate height, determined during calibration, when surveying. For example, if a beta probe's efficiency was calculated at 1/2 inch from the calibration source, the detector must be held at 1/2 inch from the surface being surveyed to maintain calibrated detection efficiency.

Note: Avoid contacting the detector probe to the area being surveyed. This potentially could contaminate the probe.

8.3.1 Verify the instrument selector switch is in the X 0.1 position.

8.3.2 For a stationary reading, place the detector over the area to be measured and allow meter to stabilize. Record the average meter indication in either CPM α/PA (probe area) or CPM β/PA on applicable forms.

8.3.3 For a scan survey move the detector slowly over the surface (less than one detector width per second). Observe meter indication. If increased readings are observed return to the area and obtain a stationary reading. Record maximum area meter indication in either CPM α/PA or CPM β/PA, on applicable forms.

8.4 Final Verification

Upon completion of work activities, repeat steps 8.1.2.1 through 8.2.2.4 and

8.2.5 through 8.2.6, as a final verification that the instrument is working properly

8.5 Interpretation of Results

The meter reading on the alpha and beta survey meters must be corrected for detector efficiency and detector surface area before comparing results with the contamination units in Section 3.6 of the Radiation Safety Program. The conversion from CPM α/PA or CPM β/PA to DPM α/100 cm^2 or β/100 cm^2 is performed using the following equation.

$$(\text{DPM} / 100\ \text{cm}^2) = \frac{(\text{AxB})}{\text{C}}$$

Where: A = Alpha or Beta survey meter indication in net CPM α/PA or β/PA (i.e. Gross Alpha or Beta Survey Counts minus background counts = Net CPM/PA)

B = 100 cm^2 divided by the effective detector surface area in cm^2. With an effective surface area of 50 cm^2 for the Ludlum 43-5 alpha detector, the value of B is approximately 2 or for the 15 cm^2 for the Ludlum 44-9 beta detector, the value of B is approximately 6.7.

C = Detector efficiency (expressed as decimal).

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 the most current and approved revision.

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 survey shall review Form OP-020-01 and any other applicable forms for accuracy and completeness.

9.2.4 Entries on Form OP-020-01 and any other pertinent forms must be dated and initialed by the HPT 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

OP-020-01 Survey Meter Source Check

Survey Meter Source Check Form

Instrument: _____ Serial No.: _____

Source: _____ Acceptable Range: _____ to _____

Date	Cal Due	Reading	H.P. Technician	H.P. Technician Initial

Review By: _____ Date: _____

APPENDIX B

Instrument Sensitivity Calculations

FIELD INSTRUMENTATION DETECTION SENSITIVITY

This appendix describes the detection sensitivities for field instrumentation used during the characterization of the New Haven Depot. This includes instruments used for gamma walkover surveys (GWS) of land areas, and instruments used for detection of contamination on building and/or structure surfaces through surface activity scans and direct measurements.

The RCOPCs at the New Haven Depot are discussed in Section 1 of the Characterization Survey Work Plan. As indicated, the RCOPCs are natural thorium and uranium. Since both were present in unprocessed ore the natural thorium and natural uranium chains remained in secular equilibrium with the parent radionuclide, as they were in nature.

The parent radionuclides in the natural thorium and natural uranium decay chains, thorium-232 (^{232}Th), uranium-238 (^{238}U) and uranium-235 (^{235}U), emit alpha particles. The daughter products in both chains decay by emission of alpha or beta particles, some with accompanying emission of gamma rays. The decay schemes for both the natural thorium and natural uranium chains are very well documented, and this knowledge is used in the design of the characterization surveys and selection of appropriate survey instruments and analysis methods.

As presented in the following sections, the NaI gamma walkover survey minimum detectable concentrations (MDCs) for natural thorium and natural uranium plus progeny in soil are:

Natural thorium: **1.3 pCi/g**

Natural uranium: **19.7 pCi/g**

Integrated or static measurement MDCs and the MDC for smear analysis are also presented in the following sections.

Gamma Walkover Survey (GWS) Detection Sensitivity

The GWS will be performed using a Ludlum 44-10 (2”x 2” NaI scintillation detector) or equivalent detector. The GWS is accomplished by a walking speed (1.5 ft/sec) walkover by the surveyor at a detector height of approximately 2-4 inches above the ground surfaces. Results are recorded in units of counts per minute (cpm).

The NaI detection sensitivities, i.e., MDC in soil, for the two RCOPCs are presented below. This evaluation assumes the RCOPCs are in the upper 15 cm layer of soil with an area of 56 cm for modeling and calculation purposes.

GWS Minimum Detectable Concentration For Natural Thorium in Soil

The methodology used to determine the NaI scintillation detector scan MDC is based on NRC NUREG –1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, December 1997. Factors included in this analysis are the surveyor scan efficiency, index of sensitivity, the natural background of the surveyed area, scan rate, detector to source geometry, aerial extent of the contamination, and energy and yield of gamma emissions.

The computer code Microshield was used to model the presence of a normalized 1 pCi/g total thorium with its 50-year decay progeny in soil with the further assumption that the activity is uniformly distributed to a depth of 15 cm and spread over a disk shaped area with a diameter of 56 cm. The uncontaminated soil cover thickness has zero thickness (contamination on the surface) and there is a 0.051 cm aluminum shield simulating the cover of the NaI detector to complete the model source term. This model is consistent with the NUREG-1507 methodology and provides for a count rate to exposure rate ratio (cpm/μR/hr) to be calculated.

The following sections provide tabulated data based upon the NUREG-1507 methodology as applied to NaI scintillation detector used in this survey, zero thickness soil cover, and a 56 cm diameter soil uniformly contaminated to a 15 cm thickness. The dose point is centered over the contaminated disk of soil.

Fluence Rate to Exposure Rate (FRER, no units)

The fluence rate to exposure rate (FRER) may be approximated by:

$$FRER \sim (1\ \mu R/hr)/(E_\gamma)(\mu_{en}/\rho)_{air}$$

Where,

E_γ = energy of the gamma photon of concern, keV

$(\mu_{en}/\rho)_{air}$ = the mass energy absorption coefficient for air, cm^2/g

The FRER over a 40 keV to 3 MeV gamma energy range is provided in Table 1.

Table 1: Fluence Rate to Exposure Rate (FRER)

Energy$_\gamma$, keV	$(\mu_{en}/\rho)_{air}$, cm^2/g	FRER
40	0.064	0.3906
60	0.0292	0.5708
80	0.0236	0.5297
100	0.0231	0.4329
150	0.0251	0.2656
200	0.0268	0.1866
300	0.0288	0.1157
400	0.0296	0.0845
500	0.0297	0.0673
600	0.0296	0.0563
800	0.0289	0.0433
1,000	0.0280	0.0357
1,500	0.0255	0.0261
2,000	0.0234	0.0214
3,000	0.0205	0.0163

Probability of Interaction (P) Through Detector End for a Given Energy

The probability, P, of a gamma ray interaction in the NaI scintillation crystal entering through the end of the crystal is given by:

$$\text{Probability (P)} = 1\text{-}e^{-(\mu/\rho)NaI(X)(\rho NaI)}$$

Where:

$(\mu/\rho)_{NaI}$ = the mass attenuation coefficient for NaI

X = the thickness through the bottom edge (end facing the soil) of the Ludlum 44-10 2"x2" NaI crystal, 5.1 cm

ρ = the density of the NaI crystal, 3.67 g/cm^3

The probability of interaction in the NaI detector over the same gamma energy range is provided in Table 2.

Table 2: NaI Probability of Interaction (P)

Energy$_\gamma$, keV	**$(\mu/\rho)_{NaI}$, cm^2/g**	**P**
40	18.3	1.00
60	6.23	1.00
80	2.86	1.00
100	1.58	1.00
150	0.566	1.00
200	0.302	1.00
300	0.153	0.94
400	0.11	0.87
500	0.0904	0.82
600	0.079	0.77
800	0.0657	0.71
1,000	0.0576	0.66
1,500	0.0464	0.58
2,000	0.0412	0.54
3,000	0.0367	0.50

Relative Detector Response (RDR)

The Relative Detector Response (RDR) by energy is determined by multiplying the FRER by the probability (P) of an interaction and is given by:

$$RDR = FRER \times P$$

The RDR for a NaI detector over the same gamma energy range is provided in Table 3.

Table 3: Relative Detector Response

Energy$_\gamma$, keV	FRER	P	RDR
40	0.3906	1.00	0.3906
60	0.5708	1.00	0.5708
80	0.5297	1.00	0.5297
100	0.4329	1.00	0.4329
150	0.2656	1.00	0.2656
200	0.1866	1.00	0.1859
300	0.1157	0.94	0.1091
400	0.0845	0.87	0.0737
500	0.0673	0.82	0.0549
600	0.0563	0.77	0.0435
800	0.0433	0.71	0.0306
1,000	0.0357	0.66	0.0236
1,500	0.0214	0.58	0.0124
2,000	0.0214	0.54	0.0115
3,000	0.0163	0.50	0.0081

Determination of Count Rate per μR/hr as a Function of Energy

The equivalent FRER, P, and finally RDR may be calculated for a NaI Scintillation detector at the cesium-137 energy of 662 keV. Manufacturers of this equipment typically provide an instrument response in terms of count rate and μR/hr at the cesium-137 energy. This point allows determination of the count rate per μR/hr and ultimately activity concentration and minimum detection sensitivity level in terms of pCi/g.

Based on measured counts in a known field it is estimated that a typical Ludlum 44-10 NaI response is 900 cpm/μR/hr and using the same methodology as shown in the tables above, the FRER, P and RDR are calculated. The mass energy absorption coefficient for air and the mass attenuation coefficient for NaI are interpolated from tables in the *Radiological Health Handbook*, Revised Edition January 1970, pages 139, and 140. These values for Cs-137 are provided in Table 4.

Table 4: NaI FRER, P and RDR For Cs-137 Gamma Energy (Ba-137m)

$Energy_{\gamma}$, keV	FRER	$(\mu_{en}/\rho)_{air}$, cm^2/g	$(\mu/\rho)_{NaI}$, cm^2/g	P	RDR
662	0.0514	0.0294	0.0749	0.75	0.0387

The detector response (cpm) to any other gamma energy is based upon the ratio of the RDR at that energy to the known Cs-137 energy RDR as shown in the following equation.

$$\text{cpm}/\mu\text{R/hr}, E_i = (\text{cpm}_{\text{Cs-137}}) \times (\text{RDR}_{\text{Ei}}) / (\text{RDR}_{\text{Cs-137}})$$

$$= (900) \times (\text{RDR}_{\text{Ei}}) / (\text{RDR}_{\text{Cs-137}})$$

The NaI count rate over the same range of gamma energies presented previously is provided in Table 5.

Table 5: NaI cpm/μR/hr, E_i

Energy$_\gamma$, keV	RDR$_{Ei}$	NaI Detector, E_i, cpm per μR/hr
40	0.3906	9078
60	0.5708	13264
80	0.5297	12309
100	0.4329	10060
150	0.2656	6172
200	0.1859	4320
300	0.1091	2536
400	0.0737	1712
500	0.0549	1277
600	0.0435	1010
662	0.0387	900
800	0.0306	711
1,000	0.0236	548
1,500	0.0124	288
2,000	0.0115	267
3,000	0.0081	188

Finally, the count rate to exposure rate ratio for natural thorium and daughters in secular equilibrium and the contribution to the total exposure rate are determined using the output of the Microshield runs and the count rate to exposure rate ratios from Table 5. The weighted cpm/μR/hr over the same energy range in previous tables is presented in Table 6.

Table 6: NaI Weighted cpm/µR/hr For Natural Thorium and Decay Products

keV	MicroShield Exposure Rate (with buildup) for 1 pCi/g ^{232}Th, µR/hr	cpm/µR/hr	Weighted cpm/µR/hr
40	3.957E-05	9078	0
60	6.309E-05	13264	1
80	7.110E-03	12309	91
100	1.815E-03	10060	19
150	2.134E-03	6172	14
200	4.142E-02	4320	187
300	3.261E-02	2536	86
400	4.042E-03	1712	7
500	2.979E-02	1277	40
600	8.114E-02	1010	85
800	1.058E-01	711	78
1000	2.360E-01	548	135
1500	7.559E-02	288	23
2000	2.136E-03	267	1
3000	3.396E-01	188	66
Total	**9.593E-01**		**833**

The scan MDC is calculated using the NUREG-1507 methodology where:

The average number of background counts in a one second interval, b_i = background cpm/60

For the Ludlum 2" x 2" NaI scintillation detector and the measured background count rate of 4600 cpm the calculated background counts in a one second measurement interval is:

$$b_i = (4600 \text{ cpm}) / 60 = 77 \text{ counts}$$

The minimum detectable count rate, MDCR is

$$MDCR = (d') \times (b_i)^{0.5} \times (60 \text{ seconds}/1 \text{ minute})$$

Where d', equal to 1.38 from NUREG-1507, Table 6.1, represents the rate of detections at a 95% true positive proportion with a false positive proportion of 60%, b_i, is the background counts in the interval determined above.

$$MDCR = (1.38) \times 8.8 \times (60 \text{ seconds}/1 \text{ min}) = 725 \text{ cpm}$$

The Minimum Detectable Count Rate for the surveyor is given as

$$MDCR_{surveyor} = MDCR/(p)^{0.5}$$

Where

p = Surveyor Efficiency, equal to 0.75 to 0.5 as given by NUREG-1507 (0.5 is chosen as a conservative choice).

$$MDCR_{surveyor} = 725/0.707 = 1025 \text{ cpm}$$

The Minimum Detectable Exposure Rate (MDER_ for the surveyor is obtained from the $MDCR_{surveyor}$ divided by the Table 6 weighted count rate to exposure rate value of 833 cpm/μR/hr for natural thorium, including decay progeny in secular equilibrium, is:

$$(1025 \text{ cpm}) / (833 \text{ cpm}/\mu\text{R/hr}) = 1.23 \ \mu\text{R/hr}$$

The scan MDC is then equal to the ratio of the MDER in the field to the exposure rate determined for the normalized 1 pCi/g concentration of natural thorium in soil as follows:

$$\text{Scan MDC} = (\text{Normalized Th}_{\text{Total Conc}}) \times (\text{Exposure Rate}_{\text{Surveyor}})/(\text{Exposure Rate}_{\text{normalized Th conc}})$$

Natural Thorium Scan MDC = (1 pCi/g) x (1.23 μR/hr)/(9.593E-1 μR/hr) = **1.28 pCi/g**

GWS Minimum Detectable Concentration for Natural Uranium plus progeny in Soil

The MDC for natural uranium (^{238}U and ^{235}U plus decay products in secular equilibrium) is determined in the same manner. The weighted count rate ratio to exposure rate (cpm/μR/hr) is presented in Table 7.

Table 7: NaI Weighted cpm/μR/hr For Natural Uranium (U-Nat) and Decay Products

keV	MicroShield Exposure Rate (with buildup) for 1 pCi/g U-Nat, μR/hr	cpm/μR/hr	Weighted cpm/μR/hr
40	7.03E-8	9078	0
60	3.40E-5	13264	8
80	3.59E-4	12309	75
100	1.61E-4	10060	28
150	5.70E-5	6172	6
200	9.09E-4	4320	67
300	2.43E-3	2536	105
400	5.61E-3	1712	164
500	3.27E-4	1277	7
600	1.03E-2	1010	177
800	2.77E-3	711	34
1000	1.10E-2	548	102
1500	8.99E-3	288	44
2000	1.58E-2	267	72
Total	**5.87E-2**		**889**

The scan MDC is calculated using the background counts in the measurement interval (77 counts), $MDCR_{surveyor}$ (1025 cpm), MDER equation and scan MDC equation from the determination of natural thorium scan MDC presented previously.

The MDER is obtained from the $MDCR_{surveyor}$ divided by the Table 7 weighted count rate to exposure rate value of 889 cpm/μR/hr for natural uranium, including decay progeny in secular equilibrium is:

$$(1025 \text{ cpm}) / (889 \text{ cpm}/\mu\text{R/hr}) = 1.15 \ \mu\text{R/hr}$$

The scan MDC is then equal to the ratio of the MDER in the field to the exposure rate determined for the normalized 1 pCi/g concentration of natural uranium plus progeny in soil as follows:

$$\text{Scan MDC} = (\text{Normalized } U_{\text{Total Conc}}) \times (\text{Exposure Rate}_{\text{Surveyor}})/(\text{Exposure Rate}_{\text{normalized U conc}})$$

$$\text{Natural Uranium Scan MDC} = (1 \text{ pCi/g}) \times (1.15 \text{ } \mu\text{R/hr})/(5.87\text{E-}2 \text{ } \mu\text{R/hr}) = \mathbf{19.7 \text{ pCi/g}}$$

Building Surface and/or Structure Surface Scan, Static Measurements and Smear Analysis Minimum Detectable Concentration

As indicated in Section 6 of the Characterization Survey Work Plan, building and/or structure surfaces will be surveyed for alpha contamination using direct surface scan and static measurement techniques. Surveys will be performed in accordance with CABRERA standard operating procedures. These surveys may be performed using a Ludlum Model 43-37 floor monitor, Ludlum Model 43-68 gas flow proportional detector, or Ludlum Model 43-89 ZnS scintillation detector. The alpha surface scan MDC for each of these detectors is provided in the following sections.

General Information on Alpha Scan MDC

Scan MDCs for alpha emitters must be derived differently than scanning for beta and gamma emitters. *MARSSIM* contains formulas and probability concepts for alpha scans in Appendix J, which provides a complete derivation of the formulas used to determine the probability of observing a count when performing an alpha scan. Additional information on various material background, detector efficiencies, surface material effects, etc. may be found in NUREG-1507.

In general, when performing an alpha scan, once a count has been recorded and the surveyor stops, the surveyor should wait a sufficient period of time such that if the guideline level (or action level) of contamination is present, the probability of getting another count is at least 90%. For low background areas (alpha background of 0 to 3 cpm), it is assumed that a single count is sufficient to cause a surveyor to stop and investigate. For higher background areas or when using larger area detectors resulting in a higher background count rates such as the Ludlum Model 43-37 floor monitor (alpha background up to 10 cpm), the surveyor will usually need to get at least 2 counts while passing over the source area before stopping for further investigation.

For the purpose of determining alpha scan MDCs, the source activity, G in the following equations, is assumed to be slightly less than 50% of the natural thorium surface activity action level presented in the Characterization Survey Work Plan, Table 3-1, i.e., 100 dpm/100 cm^2.

The assumptions pertaining to scan speeds, background, efficiency, dwell times, etc. used in the evaluation of alpha scan MDCs (probability of detection) are provided in Table 8. The probabilities of detection calculated using the equations below are also presented in Table 8. These calculations indicate that the under the conditions presented in the assumptions, the design objective of 90% probability is achieved when scanning surfaces contaminated to 100 dpm/100 cm^2 when using the indicated detectors.

Table 8: Alpha Surface Scan Assumptions

Model No.	Probe Area (cm^2)	Probe Width (cm)	α Efficiency (cpm /dpm)	α Bkgrd (cpm)	Scan Speed (cm/sec)	Pause Time (sec)	P(n>=1)	P(n>=2)
43-37	582	15	0.15*	10	6	2.5	NA	0.91
43-89 & 43-68	126	9	0.15*	3	1	7.3	0.90	NA

cm = centimeters
cpm = counts per minute
sec = second
cm^2 = square centimeters
dpm = disintegrations per minute
cm/sec = centimeters per second

* Manufacturer's stated 4π alpha efficiencies for these detectors have a range of 15 to 20%. For this evaluation, 15% is chosen as a conservative approach.

Ludlum Model 43-37 Scan MDC

The Ludlum Model 43-37 gas proportional detector is a large area detector (active area of 582 cm^2) with a higher background count rate compared to smaller area detectors, such as the Ludlum Model 43-68 or Ludlum Model 43-89. Using *MARSSIM* Equation J-7, the probability of two or more alpha counts during the scan survey of a surface is determined as follows:

$$P(n \geq 2) = 1 - P(n = 0) - P(n = 1) \quad (\textit{MARSSIM} \text{ Equation J-7})$$

$$= 1 - \left(e^{-A}\right) \times (1 + A)$$

$$\text{for } A = \frac{(GE + B)t}{60}$$

Where:

$P(n \geq 2)$ = Probability of getting 2 or more counts during the time interval t

$P(n = 0)$ = Probability of not getting any counts during the time interval t

$P(n = 1)$ = Probability of getting 1 count during the time interval t

G = Source activity (100 dpm/100 cm^2)

E = Detector efficiency (4π)

B = Background count rate (cpm)

t = Dwell time over source (seconds)

Scans will be performed by moving the active area of the detector over the surface of interest at or below the given scan speed in Table 8. If two or more counts occur over the indicated observation interval, a one-minute integrated or static measurement will be performed at that location prior to resuming the scan survey. For Class 3 survey units, if the result of the static measurement is in excess of 100 dpm/100 cm2 (slightly less than 50% of the natural thorium action level), the area will be marked for biased measurements and investigated further.

Ludlum Model 43-89 and Ludlum Model 43-68 Scan MDC

If the Ludlum Model 43-89 alpha scintillation detector or Ludlum Model 43-68 gas proportional detector is used, then *MARSSIM* Equation J-5 and the assumptions listed in Table 8, with a probability of at least one count occurring while surveying an area of contamination equal to the 100 dpm/100 cm^2 surface scan action level $P(n \geq 1)$, will be implemented instead of *MARSSIM* Equation J-7. The Model 43-89 and Model 43-68 are similar in active area and efficiency. Scans are performed the same (scan speed and dwell time) for both detectors. Although, the background may be slightly different for the two detector types, for this evaluation, they are assumed to be the same.

Using *MARSSIM* Equation J-5 and the assumptions listed in Table 8 (scan speeds, background, efficiency, dwell times, etc), the probability that a single count is sufficient to cause a surveyor to stop and investigate further is derived as follows:

$$P(n \geq 1) = 1 - P(n = 0) = 1 - e^{-A} \qquad \text{(MARSSIM J-5)}$$

$$\text{for } A = \frac{GEd}{60v}$$

Where:

$P(n \geq 1)$ = Probability of getting 1 or more counts during the time interval t

$P(n = 0)$ = Probability of not getting any counts during the time interval t

G = Source activity (100 dpm/100 cm^2)

E = Detector efficiency (4π)

d = Width of the detector in the direction of scan (cm)

v = Scan speed (cm/s)

Alpha scans will be performed using the Ludlum Model 43-89 or Ludlum Model 43-68 detector by moving the active area of the detector over the surface of interest at the scan speed shown in Table 8. Whenever a count is detected during the scan, the detector will be held in place over the location where the count was detected for the indicated pause time (approximately 7-8 seconds). If a second count is detected over this location during the pause time, a one minute integrated count will be performed. For Class 3 survey units, if the result of the static measurement is in excess of 100 dpm/100 cm2 (slightly less than 50% of the natural thorium action level), the area will be marked for biased measurements and investigated further.

Integrated Direct Surface Measurements and Smear Analysis

Integrated direct measurements (i.e., static measurements) of surface alpha contamination will be performed to compare contaminant concentrations at discrete sampling locations to the appropriate action level. Smear samples will be collected at biased building surface locations, as appropriate, to quantify transferable surface alpha contamination.

Integrated alpha activity measurements will be performed using a Ludlum Model 43-37 gas proportional detector, Ludlum Model 43-68 gas proportional detector, Ludlum Model 43-89 handheld scintillation detector, or equivalent. Again, the parameters and static measurement requirements are very similar for the Ludlum Model 43-68 and Ludlum Model 43-89 detectors. For the purpose of this evaluation, the same parameters are used for both detectors. Smears will be analyzed using a Ludlum Model 43-10-1 smear count detector attached to a Ludlum Model 2929 ratemeter, or equivalent. The static measurement and smear analysis MDC and assumptions used for each of the detectors are presented in Table 9. The MDC was determined using Equation 3-11 of *NUREG 1507*. For comparison, the action levels applicable to the New Haven Depot are presented in Table 3-1 of the Characterization Survey Work Plan.

Table 9: Static Survey and Smear Analysis MDC and Assumptions

Model No.	Count Time (min)	Bkg Count Time (min)	Probe Area (cm^2)	α Efficiency (cpm/dpm)	α Bkg (cpm)	α Static MDC (dpm/100 cm^2)
43-37	1	1	582	0.15*	10	20
43-89 & 43-68	1	1	126	0.15*	3	60
2929	4	20	Smear	0.39	2	8

min = minutes
cpm = counts per minute
cm^2 = square centimeters
dpm = disintegrations per minute

* Manufacturer's stated 4π alpha efficiencies for these detectors have a range of 15 to 20%. For this evaluation, 15% is chosen as a conservative approach.

Summary

GWS, scan survey, static measurement and smear analysis MDCs have been calculated for each instrument to be used during the New Haven Depot characterization. Calculation of MDCs for each instrument ensures that direct measurements are performed using radiation survey instrumentation sufficient to evaluate radiological conditions in accordance with the requirements of the Characterization Survey Work Plan. Due to the potential variations of conditions in the field, parameters such as static measurement and smear count times may be adjusted onsite with the permission of the CABRERA project health physicist.

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