SURVEY PROCEDURES MANUAL FOR THE INDEPENDENT ENVIRONMENTAL ASSESSMENT AND VERIFICATION PROGRAM

CONTROLLED MANUAL___________UNCONTROLLED MANUAL_________

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OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION
Managed by ORAU for the U.S. Department of Energy

TABLE OF CONTENTS AND RECORD OF REVISIONS

APPROVALS

All procedures identified in the Revision 20 Table of Contents and Record of Revisions have been reviewed an approved by:

Program Director:______________________ Date: 5/1/2008

Survey Projects Manager:______________________ Date: 5/1/2008

Quality Manager:______________________ Date: 5/1/2008

Section 1.0

Introduction

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Section 1.0 – Introduction

The Oak Ridge Institute for Science and Education (ORISE), as one of its core competencies through the Independent Environmental Assessment and Verification Program (IEAV), **conducts radiological survey activities** under a contract with the U.S. Department of Energy (DOE) and for the U.S. Nuclear Regulatory Commission (NRC) under interagency agreements. ORISE and its programs are operated by Oak Ridge Associated Universities (ORAU) through a contract with DOE.

Sites surveyed under this program are primarily those where residual contamination from previous operations may pose a potential risk to the environment of the site or the health and safety of those occupying the site presently or in the future. Other activities include monitoring of radioactive effluents from currently operating facilities and miscellaneous technical assistance to the funding agencies.

The **purpose** of this *IEAV Survey Procedures Manual* is to provide a standardized set of procedures that document activities of the program in an auditable manner. These procedures are applicable to both the DOE and NRC operations. Procedures presented here are limited to those associated with site survey activities. Detailed operating or troubleshooting procedures for specific program equipment are not provided here – the reader is referred to manufacturer's instructional manuals for such information. Additionally, procedures related to the radiological laboratory analytical functions and the quality assurance program are presented in separate documents (*IEAV Laboratory Procedures Manual* and *IEAV Quality Program Manual*, respectively).

It is important to note that the information presented within this document is intended to serve as the **standard operating procedures (SOPs)** for ORISE survey activities. However, due to site- and project-specific requirements that may occur or be requested, the SOPs may be modified to meet project requirements. In accordance with the *IEAV Quality Program Manual*, any deviations to procedures are documented with the technical basis for the modification.

This manual was produced through the combined effort of many ORISE staff members, both past and present. Their contributions are greatly appreciated.

Section 2.0

Organization & Responsibilities

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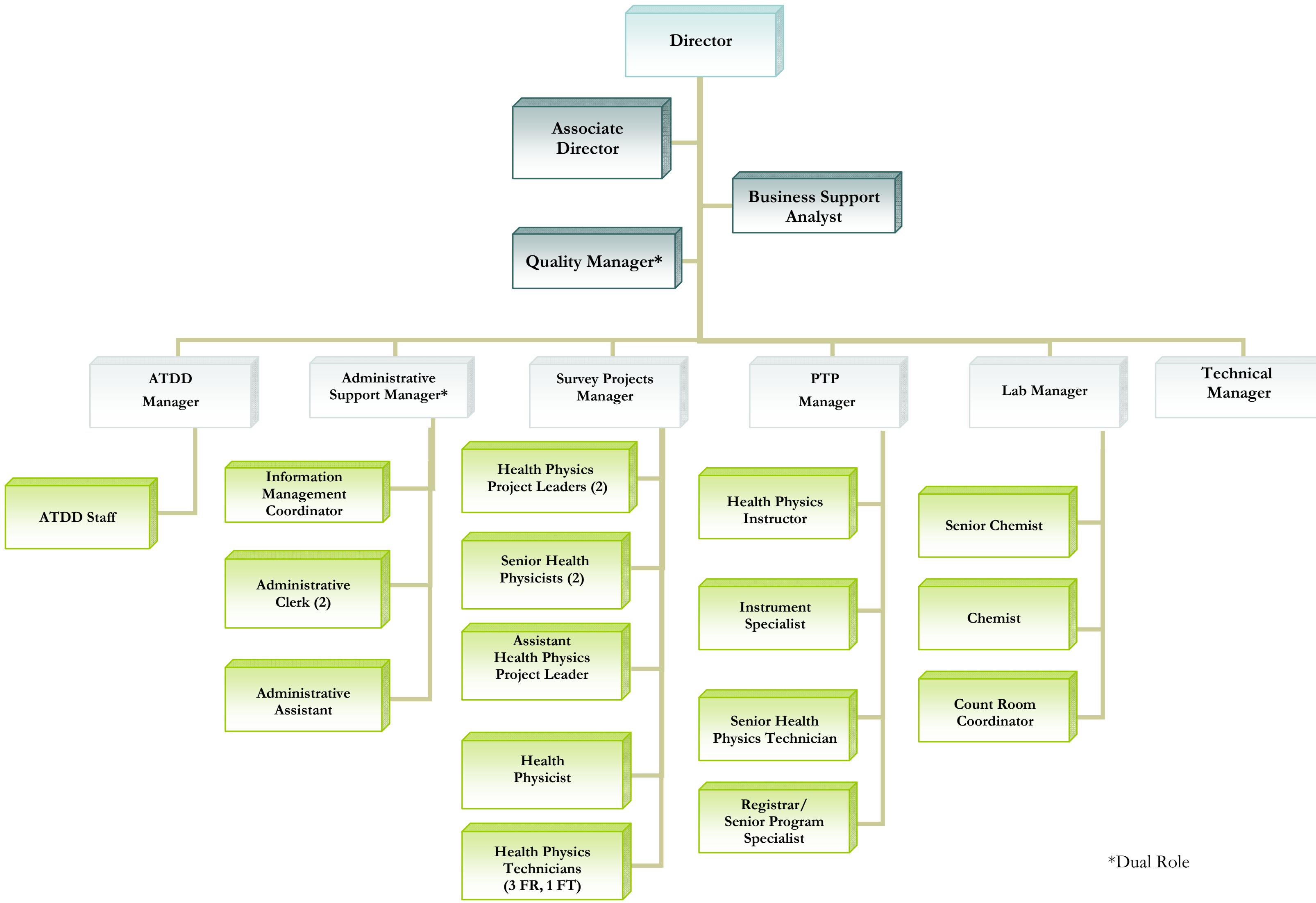
Section 2.0 – Organization & Responsibilities

As previously stated in Section 1.0, the **Oak Ridge Institute for Science and Education (ORISE)**, as one of its core competencies through the **Independent Environmental Assessment and Verification Program (IEAV)**, conducts radiological survey activities under a contract with the U.S. Department of Energy (DOE) and for the U.S. Nuclear Regulatory Commission (NRC) under interagency agreements. ORISE and its programs are operated by **Oak Ridge Associated Universities (ORAU)** through a contract with DOE.

The figure on page 2 of this section represents the generic organizational structure of the IEAV survey staff. Detailed responsibilities for various staff positions are documented in Position Questionnaires, which have been developed for all employees. Additional information is included in the *IEAV Quality Program Manual*.

The **Survey Projects Manager** is responsible for initiating the development and periodic revision of procedures related to field survey activities at any time as may be determined to be necessary. Field survey procedures require review and approval from the Survey Projects Manager and the **Program Director**. The **Quality Manager** must concur and is responsible for distribution and control of procedures. The authority for interpretations of procedures resides with the Survey Projects Manager but may be delegated to the level of the field Site Coordinator.

Site Coordinator is a generic title which applies to any individual designated as ORISE's representative and on-site supervisor and it does not appear in the organization chart. With respect to the field survey activities, it is the responsibility of the Site Coordinator to assure that these procedures are followed by all personnel performing environmental surveys and to continually evaluate results for accuracy and precision. It is the responsibility of each individual that is conducting surveys to abide by all aspects and details presented in this manual and to report deviations or abnormal results to the responsible supervisor.


Director
Associate Director
Business Support Analyst
Quality Manager*
ATDD Manager
Administrative Support Manager*
Survey Projects Manager
PTP Manager
Lab Manager
Technical Manager
ATDD Staff
Information Management Coordinator
Administrative Clerk (2)
Administrative Assistant
Health Physics Project Leaders (2)
Senior Health Physicists (2)
Assistant Health Physics Project Leader
Health Physicist
Health Physics Technicians (3 FR, 1 FT)
Health Physics Instructor
Instrument Specialist
Senior Health Physics Technician
Registrar/ Senior Program Specialist
Senior Chemist
Chemist
Count Room Coordinator

*Dual Role

Section 3.0

Summary of Activities

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Section 3.1 – Summary of Activities

Assignments are received from the NRC, DOE, or other Federal funding agencies. These agencies provide background information concerning the site history, type of survey desired, and scheduling requirements. The funding agency also provides names of site contacts and obtains site access consent when necessary.

A **scoping visit** is usually performed by a Project Leader to gather additional details concerning the site. Such details include:

- a site-specific health and safety analysis;
- area and building descriptions;
- site accessibility for gridding and surveying;
- special equipment requirements;
- security arrangements;
- site contacts;
- recommended local accommodations;
- area maps and photographs;
- other pertinent information obtained through reviews of records and reports of the regulatory agencies.

A **proposed survey plan** is prepared for submission to the funding agency. Due to differences in sites, each plan is site-specific. Factors considered in the plan include:

- the type of survey,
- site size and complexity,
- operational history,
- potential radionuclides present, and
- available manpower and equipment resources.

The **survey plan** may require modification based on findings as the survey progresses. The plan is written to allow for such field changes. It is the responsibility of the Project Leader to make appropriate changes to the plan. The Site Coordinator is responsible for ensuring changes in the plan are implemented at the field location. All such changes must be documented in the site logbook or on the appropriate field survey forms. Subcontracts and purchase requisitions for specialized services and equipment are initiated.

When the survey plan has been approved both internally and by the funding agency and the schedule finalized, the Project Leader and Survey Projects Manager select personnel for the survey and the Site Coordinator prepares a listing of supplies and instruments required. Travel arrangements are also initiated once the Project Leader submits the Travel Authorization Request.

The survey is performed in accordance with the survey plan. All data collected on site is brought back to the ORISE facility for interpretation and samples collected for radiological analysis are delivered to the IEAV radiochemistry laboratory in Oak Ridge for analysis. A **final report** of the survey results is provided to the client, and may be preceded by issuance of a draft report for initial review and revision.

As part of its core competencies and within its operations, the ORISE conducts the following major categories of radiological surveys with each survey type having specific data quality objectives (DQOs):

Preliminary Survey (designation, screening, or inclusion) **–** Limited investigation to determine if radiological conditions warrant in-depth evaluation. The DQOs of the preliminary survey are:

- Problem: A site has been identified with a history of radiological operations for which the current radiological conditions of land or building areas are unknown or available data are insufficient.
- Decisions: Is contamination present in suspect areas that require further site investigation?
- Decision Inputs: Review of available historical processes and documentation; identification of probable radionuclides of concern (ROCs); judgmental, limited quantity radiological data sufficient to establish whether contamination is or is not present.
- Study Boundaries: Determined based on documentation review, high probability areas selected for investigations.
- Decision Rule: Contamination is or is not present above a pre-determined threshold. The threshold may be background, former regulatory limits, current regulatory limits, or a fraction thereof.
- Decision Errors: Because of limited project scope, the decision error is limited to incorrectly determining that contamination is not present.
- Optimize the Survey Design: Ensure adequate knowledge is obtained regarding the ROCs for instrument selection and concentrate surveys (consisting primarily of scanning with limited sampling and measurements) in identified high probability areas.

Characterization Survey (scoping, comprehensive) **–** Thorough measurement and sampling to determine the extent and levels of site contamination. This survey is used to establish requirements for remedial action. The DQOs for the characterization survey are:

- Problem: The radiological classification of a site and the contamination extents must be determined.
- Decisions:
  - Is contamination present?
  - Are soils, building surfaces, or other media impacted?
  - What are the levels relative to appropriate release criteria?
  - What are the boundaries of contamination?
  - What is the estimated decommissioning scope?
  - What other data must be collected to support other activities such as dose modeling?
- Decision Inputs: Broad scope, primary radiological data that are used to confirm ROCs and ratios, determines the overall levels of contamination and areal extent of contamination, and may also support no further action alternatives for areas where contamination levels are found to be below release criteria. Data are both judgmental and statistically-based.
- Study Boundaries: Spatial, temporal, and practical survey boundaries are set to better define the required data for making decisions, survey area sizes and initial classifications are selected.
- Decision Rule: Specific decision rules are project-specific. However, the decision rule for ORISE scoping/characterization survey activities are typically to (1) identify and bound gross contamination, (2) determine activity ranges, (3) include or exclude survey areas from remedial action, (4) determine the mean concentrations in survey areas, and (5) assess whether mean concentrations and maximum limits are acceptable to use as final status survey data.
- Decision Errors: Decision errors are project specific and determined independently.
- Optimize the Survey Design: The scoping/characterization survey design is determined individually for project. A graded approach is used with specifics on number and type of samples determined on a case-by-case basis.

In-Process Inspections and Verification/Confirmatory Surveys – Independent evaluations and limited measurements are performed to evaluate the adequacy and accuracy of decommissioning survey procedures, processes, and technical bases, to determine compliance with regulatory guidance and regulations. The in-process inspection is a streamlined approach designed to evaluate larger sites and ensure the adequacy early on in the decommissioning project and reduce the reliance on large, end-of-project confirmatory surveys.

- <u>Problem</u>: The adequacy of the licensee's final status survey design, implementation and documentation for demonstrating compliance with the release criteria must be determined.
- <u>Decisions</u>:
  - Has the licensee prepared an adequate FSS plan in accordance with guidance documents?
  - Were field and laboratory instrumentation used or planned to be used adequate/appropriate for scanning, direct measurements, and analysis for the radionuclides of concern (ROCs)?
  - Did calibration account for the ROCs?
  - Were the FSS data adequately documented and support the licensee's decision regarding final radiological status?
  - Are the licensee's results representative of current radiological conditions?
- <u>Decision Inputs</u>:
  - Review of ROCs, area classification, survey unit size, estimated mean and standard deviation.
  - Review of the methods used to address the impact of multiple ROCs in FSS planning.
  - Review of instrument use procedures:MDC calculationsactual vs. required scan sensitivity calibration, including accounting for multiple radionuclides and any environmental factors that may influence instrument performance.
  - Review of analytical procedures for appropriateness for measuring the ROCs.
  - Cross-checking of FSS data packages against plan requirements.
  - Using verification/confirmatory survey and analytical results to assist with evaluating facility radiological status.

In-Process Inspections and Verification/Confirmatory Surveys (continued)

- Study Boundaries:
    - Select FSS data packages for review.
    - Select appropriate planning documents (or sections thereof) for review.
    - Select survey units/areas for confirmation.
    - Determine scan coverage based on classification.
    - For soil sampling, determine sampling depth requirements and sampling intervals. At a minimum samples would be collected from anomalous or other judgmental areas together with selected licensee archived samples for confirmatory analysis. The necessity for, and the specific numbers of, other random/systematic samples is separately evaluated using the DQO process.
    - For structure surfaces, direct measurements should be limited to anomalous or judgmental areas and comparative measurement locations. The necessity for, and the specific numbers of, other random/systematic samples is separately evaluated using the DQO process.

- Decision Rule:
    - If compliance has been adequately demonstrated with complete, accurate project documentation representing current radiological conditions relative to the release criteria, then recommend acceptance; if insufficient, then provide technical comments.
    - Calculate action levels to investigate anomalies identified during verification/confirmatory surveys.
    - Evaluate anomalies identified during verification/confirmatory surveys for compliance:
      (1) Is it acceptable relative to size and concentration?
      (2) Has the licensee adequately addressed it previously?
      (3) Is it consistent with the survey unit classification?
    - There is or is not agreement of confirmatory analyses or measurements with the site's reported results.
    - Systematic agreement and judgmental samples and measurements are less than the DCGL.

- Decision Errors:
    - For comment resolution, determine the significance of each issue and implications of the comment relative to either the survey planning, survey performance, data generated, and/or overall conclusions for the site's status.

- For confirmatory survey results contrary to the site's, what is the magnitude of the finding (number of anomalies identified, size of the anomalies, classification of the area where they were identified) and what is the proposed remedy.
- For multiple anomalies, determine the root cause and reevaluate DQOs. Confirmatory analysis/measurements should agree within expected statistical deviation of the procedure: if disagreement, determine root cause, otherwise recommend acceptance.

- Optimize the Survey Design: Ensure involvement at an early stage of the project, preferably at the time the FSS plan is first being drafted, critical for successful and cost effective verification of small sites. For larger sites requiring more than one visit, implement the streamlined, in-process inspection approach.

Section 3.2 – Job Hazard Analysis – Survey Mobilization and Demobilization

DISCUSSION: Job hazards associated with survey mobilization and demobilization are minimal. General duty hazards do exist and are presented below together with standard controls.

JOB HAZARD ANALYSIS		
ACTIVITY	**HAZARDS**	**CONTROLS**
A. Packing/unpacking equipment	A1. Back injury	A1. Use proper lifting techniques
B. Loading equipment	B1. Back injury	B1. Use proper lifting techniques
C. Transporting equipment	C1. Compressed gas hazards	C1. Cap all cylinders, secure cylinders using straps or use transport boxes, use packing box when transporting the pressurized ionization chamber.

Section 4.0

Quality Assurance & Quality Control

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Section 4.1 – QA/QC General Information

The ORISE Survey Program conducts field surveys in a manner that assures the quality and accuracy of developed data and provides auditable documentation of activities.

Details of the field quality assurance and quality control procedures have been integrated throughout this document. These procedures are an extension of the quality assurance program as documented in the *IEAV Quality Program Manual*.

Section 4.2 – Training and Certification

Purpose

To describe the training and certification (or recertification) process used to qualify ORISE survey personnel to perform procedures related to program activities.

On-The-Job Training

Staff Member	Responsibility
Survey Projects Manager	• Oversee development and implementation of training programs, including approval criteria. • Determine the methodology that will be used for providing training on processes and procedures. • Identify staff members requiring training. • Identify procedures for which training, proficiency testing, refresher training, and re-certification are required. • Approve proficiency testing criteria. • Review completed training documentation. • Ensure training/certification documentation is current for staff.
Trainer	• Must hold current certification. • Perform instruction for training of individuals. • Observe and document performance of trainees.
Project Leader	• Assist in identifying training needs for individuals. • Initiate training and certification for individuals, as required. • Ensure required training for specific projects is successfully completed.
Quality Manager	• Oversee maintenance of training records.
Administrative Staff	• Maintain ORISE survey staff training records.
Trainee	• Read procedure and discuss it with a trainer. • Observe and assist with the performance of a procedure by a trainer. • Perform the procedure in the presence of a trainer. • Complete appropriate documentation indicating that the significant steps of the procedure are understood and/or are performed.

Certification Process

The specific training process required for certification is determined by the Survey Projects Manager.

- Procedures are documented in the ***IEAV Survey Procedures Manual*** or, for new or project specific procedures, in stand alone documents.
- **Indoctrination/orientation training** is conducted to provide the employee with basic information about portions of program activities.
- The **training instruction** will include reading the procedure and may also include oral discussions, written testing, hands-on demonstration of proficiency, or a combination of these to ensure that individuals understand the following:
  - ✓ Purpose and the correct application of the procedure.
  - ✓ Associated safety hazards and required personal protective equipment (PPE).
  - ✓ Related policies/procedures.
  - ✓ Conditions requiring supervisory approval before proceeding.
  - ✓ Applicable quality control requirements.
- The trainer will complete a **checklist** indicating that the significant steps of the procedure have been correctly performed to ensure consistent documentation.
- Initial training on a **new procedure** will be conducted by the staff member responsible for development of the procedure. In this case, the developer will be designated as certified by the appropriate supervisor, by virtue of the knowledge gained during procedure development and testing.
- **Records** documentation for training are reviewed by the Survey Projects Manager and are kept in individual files, under the cognizance of the Administrative Staff.
- **Re-certification** will be done at least annually (competency may be demonstrated by field personnel by performing standard procedures on the job during each annual cycle), when procedures have been modified, or new procedures developed.

Compliance Training

Additional training may be required to maintain compliance with federal regulations, or client, corporate, and/or site-specific requirements. Some examples of the types of additional training may include, but are not limited to:

- OSHA Hazardous Waste Operations and Emergency Response Standard (HAZWOPER)
- First Aid/CPR
- RadWorker II
- Specific training relating to health, safety, and emergency procedures required for access to and/or work on, some field sites.
- Other safety related training, as required.
- ORISE mandatory training.

Developmental Training

Although developmental training is not required, it may be desired to increase a specific skill set for an individual or a work group. The identification of these continuous improvement opportunities may arise after the acquisition of new equipment or software, may be defined in an Individual Performance Plan (IPP), or may result from a needs assessment. Approval must be granted by the Survey Projects Manager.

Section 4.3 – Records and Reports

Introduction

Accuracy in collection and reporting of survey data are critical throughout the survey process. Proper documentation increases confidence in the data reliability and provides a mechanism for monitoring quality. The **Site Coordinator** is the designated team member responsible for ensuring that the project information is documented correctly.

Critical records are those that contain information essential to the audit trail of the project. These records may be in several forms including area maps, standard record forms, handwritten notes, or figures illustrating sample locations. Additionally, a site **logbook** will be maintained by the Site Coordinator which serves as the daily journal and notebook for the project. Logbook entry requirements are outlined in the *IEAV Quality Program Manual* and include the following:

- Logbook should document major decisions, verbal communications, work activities, and other pertinent information;
- Equipment malfunctions and project deviations must be recorded with the circumstances requiring deviation and alternate approach;
- Critical record inventory and a summary of the day's activities should be recorded prior to leaving the field site.

Electronic records may be substituted, provided appropriate access authorization procedures are in place and quality assurance requirements are met.

Pre-Survey

A site-specific **survey plan** is developed prior to the start of on-site activities. The plan should provide descriptions of:

- Areas to be surveyed;
- Unit classifications and scan coverage;
- Instrumentation to be used;
- Types of samples to be collected;
- Anticipated sampling frequency;

- Procedure identification;
- Health and safety issues and/or plans;

Often, changes in the survey plan are necessary due to unanticipated findings as the survey progresses or at the request of the funding agency. The Site Coordinator has the authority to make changes to the plan, after consultation with others, if necessary, on technical matters. Modifications not directly requested by the funding agency must have a defensible technical basis and a change of any kind must be documented in the site logbook.

Survey

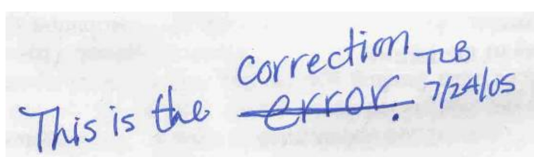
All **data**, **notes**, **measurements**, **calibrations**, and other information pertinent to a survey site must be recorded and maintained. Records must conform with the following basic requirements:

- Marked with date of entry.
- Signed (or initialed) by the author of the entry.
- Written or printed, in pen, in a legible manner.
- Contain all pertinent information in a concise, accurate entry.

The Site Coordinator is responsible for reviewing data for accuracy and completeness before on-site activities are concluded.

Pre-designed **forms** should be used to prompt the surveyor for specific information and provide consistency in recording data. If specific site situations require a change of pre-printed information, corrections must be made as shown below.

If data **corrections** are necessary a single line will be drawn across the entry. New data, initials of the surveyor, and date of correction will be recorded (see illustration below). Data will not be obliterated by erasing or use of white-out.



When certain information requested on the presented form is not required, the space or columns should be crossed through or marked "NA" (not applicable) as an indicator that an entry was not inadvertently forgotten.

Original **drawings** and **maps** may first be drawn in pencil but must be made permanent by tracing in ink or producing a photocopy prior to the addition of data to the page.

In some instances imaging equipment such as still or video cameras may be used to document site orientation, site conditions, equipment, etc. Such equipment should be operated in accordance with the manufacturer's instruction manuals. **Images** shall be considered critical records if used for documentation of measurement or sampling locations.

Post-Survey

All records relative to a specific site are reviewed and retained by the Project Leader until the report has been prepared. Records must be **protected** from loss, damage, tampering, or unauthorized access by keeping them under surveillance or in a secured storage location.

The results of surveys are documented in **reports.** The report format is selected to meet the customer's needs and may be in the form of a **letter report** or a full **final report** (either of which may be preceded by a **draft report** for initial review and revision). The complexity and style of the report and its distribution are determined based on the type of survey and the requirements established by the customer (funding agencies such as the DOE, NRC, or other).

Internal review of both draft and final reports will be performed according to requirements of the *IEAV Quality Program Manual*. Survey reports are provided only to the funding agencies whom are then responsible for the distribution of all information concerning the surveys.

Following release of the final report to the funding agency, all records, background information, and other information relative to the site are **archived** for permanent storage according to the requirements established in the *IEAV Quality Program Manual*.

Physical media can be either a hard copy or electronic format stored on disk or the network drive. Locations of electronically archived critical records must be identified in the project file.

Section 4.4 – Equipment and Instrumentation

Introduction

New equipment and instrumentation items are uniquely identified upon receipt with either an **ORISE property number** or a departmentally assigned **bar code number** to allow for independent traceability of each item.

Calibration and operational check-out sources are purchased from manufacturers in accordance with procurement specifications.

Instrument Calibration

Calibrations of field instrumentation will be based on standards traceable to the National Institute of Standards and Technology (NIST). In those cases where NIST traceable standards are not available, the Survey Projects Manager may approve use of standards of an industry recognized organization, e.g. the New Brunswick Laboratory for various uranium standards.

Calibration procedures will be performed according to the appropriate subsections within Section 5.0 of this manual. These procedures are in accordance with recommendations of the following standards:

> *ANSI N323A-1997, American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments. 1997.*
>
> *International Standard. ISO 7503-1, Evaluation of Surface Contamination - Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters. August 1, 1988.*
>
> *NUREG-1507. Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. U.S. Nuclear Regulatory Commission. Washington, DC; June 1998.*

Efficiency calibrations are performed prior to initiating surveys at a new site or a special field project, every six months when used for an extended period at a single site, if an instrument fails a performance check, or if an instrument has undergone repair or any modification that could affect its response. Electronic calibrations are performed annually (at a minimum) or following repair. The PIC is calibrated by the manufacturer biennially (when in use) and after repairs.

Items sent to the manufacturer for calibration will have an operational check performed on return to ensure that no damage occurred during shipment.

Calibration documentation will be reviewed and approved by the responsible manager or supervisor prior to the next use of the item.

Instrument Operational Checks

Counts of check sources will be performed for field instruments prior to and at the end of each day's use.

The Survey Projects Manager will establish acceptable performance ranges or criteria for the operational parameters to be monitored. Manufacturers' specifications, contractual requirements, industry standard procedures, or operational experience may be the basis of the performance criteria. Criteria will be established to achieve project goals.

The Survey Projects Manager will determine the method and frequency of monitoring appropriate for various parameters and the method of documenting the monitoring results. Operational performance data may be recorded, utilizing software inherent in equipment computer systems, or handwritten in logbooks or on specially developed forms. In addition to data tabulation, data may also be charted to enable improved visual presentation of trends and comparison with acceptance criteria.

Operational performance data will be reviewed for completeness, conformance with acceptance criteria, and appropriate resolutions or corrective actions, and to determine if there are trends that could indicate possible deterioration of system performance.

Requirements for monitoring operating parameters are incorporated into the appropriate procedure for the equipment or activity, along with the performance criteria, required actions, and any additional requirements for special statistical evaluations, associated with the review/evaluation process.

Establishment of Background Control Chart for Calibration

For each instrument, a series of 30 measurements will be taken in an area representative of background conditions. Site-specific backgrounds are determined in accordance with Section 5 of this manual.

Calculate the average of the 30 measurements and the standard deviation (sigma [σ], $\pm$ 2 σ, and $\pm$ 3 σ). Record these results on the electronic spreadsheet, or equivalent data storage location.

The background operational parameters will be re-established if any of the following occurs:

- Instrument consistently does not meet parameters that have been established.
- Instrument receives extensive repairs.
- A new instrument/detector combination is used.

Cross–Contamination Prevention for Equipment

All equipment and instrumentation used in potentially contaminated areas is to be scanned, and cleaned if necessary, prior to leaving the site to assure that contamination is not inadvertently moved out of controlled areas and does not interfere with accuracy of subsequent measurements. The results of these scans must be documented in the site logbook.

When there is a potential for contamination of containers or vehicles during sample transport, suspect surfaces will be surveyed. Should decontamination be necessary, a follow-up survey will be performed to assure that all surfaces maintain activities that are as low as reasonably achievable. Surveys of equipment or other items should be documented in the site logbook.

Section 4.5 – Sample Handling

Purpose

To describe the approach for the maintenance of sample accountability, field control of cross contamination, and sample screening for laboratory contamination control.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented on site.
- Survey team personnel are responsible for following this procedure.
- Other specific responsibilities are described under the appropriate subsection.

Sample Chain-of-Custody

Sample accountability and integrity is maintained by use of the chain-of-custody procedures in Section 8.16.

Sample custody documentation is initiated upon collection or receipt of the samples by ORISE and continues until the samples are consumed in analysis, transferred to another organization, or disposed of properly.

An acceptable chain-of-custody is maintained when the sample is under direct surveillance, kept in a tamper-free container, or is within a controlled access facility.

Samples collected by other organizations that are provided to field personnel will have chain-of-custody initiated for them by the individual receiving the samples.

When the organization has an established chain-of-custody in place, a copy of the originating form will be attached to the ORISE form.

Field Control of Cross-Contamination

Equipment and supplies used for collection and storage of samples must be handled in such a manner as to prevent accidental cross-contamination. The degree of concern and precautions followed will be determined by the specific site conditions and activity levels involved. Equipment used for sample collection should be surveyed, and cleaned as necessary, following each use.

Site history and monitoring routinely performed at the sampling location will provide an indication as to the need for special attention to decontamination following sampling. Any necessary decontamination should be performed such that potentially contaminated waste, generated in the process, can be collected and assessed to determine the appropriate disposal method.

The equipment used for decontamination should include:

- ✓ tap water
- ✓ deionized water
- ✓ non-phosphate detergent
- ✓ isopropyl alcohol (special shipping regulations apply)
- ✓ spray bottles
- ✓ stiff bristle brush
- ✓ paper towels

To prevent potentially contaminated sampling equipment from possibly cross-contaminating subsequent samples, the equipment should be cleaned as follows:

1) Wipe equipment surfaces free of loose material using paper towels or pre-moistened towelettes.
2) Rinse with tap water.
3) Wash with detergent solution and brush, if available or required.
4) Rinse with deionized water.
5) Rinse thoroughly with isopropyl alcohol, if available or required.
6) Allow to air dry.

All samples known or suspected of containing levels of radioactivity which could present a contamination or exposure problem in the field or laboratory are to be placed in clean outer containers and identified with a radiation warning label or other explanatory information, as appropriate in accordance with the ORISE sample screening requirements.

Screening Samples for Laboratory Contamination Control

The following responsibilities are assigned to the corresponding staff:

Site Coordinators/Laboratory Manager –

- Evaluate projects to identify those with potential for samples containing activity levels that may require special laboratory handling.
- Document in the project file (e.g., memo, logbook, safety plan, etc.) the need for screening and the screening method and action levels, if appropriate, to be used.
- Provide direction to sample collectors and those performing log-in as to screening and records requirements.
- Develop a listing of samples from each project which exceed the activity levels requiring special handling and submit with the laboratory work request.

Field Survey Personnel (sample collectors) –

- Label the sample container and note on the collection record form those samples in categories requiring special handling. This may include using a colored tape to indicate the screening level (e.g., yellow for moderate, red for high) to draw attention for the sample processors.
- During log-in, record screening information in the sample database and confirm proper container labeling.

Laboratory Personnel/Field Survey Personnel –

- During log-in of samples not previously screened by ORISE personnel, such as samples received from outside organizations, perform sample screening, label containers requiring special handling, and record findings in the sample database.

The following three categories of samples have been established for the purpose of controlling contamination in the laboratory during sample analysis:

Low Activity (LA)—Samples containing **< 1000 pCi/g (soil/sediment) or < 1000 pCi/L (liquid)**. Samples of small size, e.g., smears, are limited to 1000 pCi total activity, when the activity is dispersable (i.e., in other than a solid matrix) or the analysis entails other than strictly physical operations (weighing or direct counting).

Moderate Activity (MA)—Samples with activity levels **between 1 and 100 times the upper limits for the Low Activity category**.

High Activity (HA)—Samples containing **greater than the Moderate Activity** category limits.

On the basis of empirical data, responses of typical field survey instruments to samples containing Moderate Activity and High Activity levels of some commonly encountered contaminants have been determined. These response data are summarized in Table 1 of this section. Action levels from Table 1 may be used when potential sample contaminants would be expected to provide comparable instrument responses. Action levels for other contaminants or mixtures of contaminants, for which a comparable material is not provided, may be chosen on the basis of conservative assumptions and expected instrument response characteristics.

Certain contaminants (for example, very low energy pure beta emitters, and pure alpha emitters in soil and water) **will not be detectable** even at the Moderate Activity and/or High Activity levels using direct monitoring methods. Site history and other analytical data (if available) may be used as a basis for initially identifying samples as potentially containing levels requiring special laboratory handling. A conservative estimated activity level should be assumed. Any such samples would, in addition to the activity category, be further identified as "Suspect".

Prior to collection of samples (or receipt of samples that are submitted directly to the laboratory by other organizations), **the cognizant project supervisor will evaluate the potential** that samples may contain activity levels in excess of the Low Activity category limits. If it is determined that such a potential does not exist, that evaluation is documented by a note to the project file, a notation in the project logbook, a statement in the project Safety Plan, or other documentation in the permanent record.

If it is determined that there is a potential for receiving samples containing Moderate Activity and/or High Activity levels, **a plan for screening** will be developed by the project supervisor. The plan will identify:

- potential radionuclide contaminants which may exceed Low Activity levels
- areas of the survey site from which samples may contain such levels
- screening techniques (instruments, site history) to be used
- instrument response action levels (if appropriate) to be used for designating categories

This information becomes part of the project file; project personnel will receive instruction in its implementation.

At the time of collection by ORISE personnel, those samples containing other than Low Activity levels (by virtue of field measurements, site history, or sample characteristics) will be identified. **Identification tape will be affixed** to the containers and a notation will be added to the sampling record form. High activity samples will be labeled with red tape and medium activity samples with yellow tape. Samples for which screening by direct monitoring is not applicable, which are suspect for other reasons, will also include the wording "Suspect."

When samples are to be received from another collecting organization, the ORISE project supervisor will request the providing organization to include information as to the anticipated activity levels and to identify those specific samples suspected of containing Moderate Activity and High Activity.

During log-in, samples received from other organizations will be monitored by direct measurement to confirm (where possible) the activity category. Again, the information in Table 1 will provide guidance as to the category levels. Those samples not previously identified as requiring special handling, will be labeled. Categories and screening level data will be noted on the containers and in the sample database.

Guidance for performing sample screening

1. **Select the instrument** which will provide the greatest sensitivity for the potential contaminant.
2. **Scan the sample** to locate the point of maximum direct radiation. The scan and measurement should be performed in a manner that provides an optimum condition for identifying activity, but prevents the possibility of contaminating instruments, personnel, and other samples. For example, soil samples may be monitored through the plastic collection bag and smears may be monitored directly, while avoiding contact between the detector face and the smear.
3. **Determine the maximum** direct contact radiation level and **compare** with the appropriate action levels for sample category.
4. **Note** the screening category on the sample **label** and in the sampling record **form** or sample database, as appropriate.
5. Where direct screening methods are not sufficiently sensitive to identify activity levels of the Moderate and High categories, but the sample is suspected for other reasons of containing such levels, enter the notation **"Suspect"** on the sample label and in the sample database.

In certain cases, other routine measurements may be sufficient to categorize a sample, without additional screening. Examples are: (1) where surface activity measurements indicate a total activity level below the upper limit for Low Activity Samples, screening of smears will not be necessary, and (2) when in-situ soil contact gamma measurement indicates that a sampling location does not potentially contain elevated concentrations of gamma emitters, gamma screening of the sample will not be required.

The cognizant supervisor will prepare or direct preparation of the Lab Work Request, such that analyses of samples of Low, Moderate, and High activity are requested separately and that Lab Work Requests include notation as to the sample activity category

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Section 4.6– Job Hazard Analysis – Sample Screening

Discussion: Each survey site is unique and the specific hazards associated with media sampling vary from site-to-site. Normally expected hazards associated with these tasks are provided below together with standard controls.

JOB HAZARD ANALYSIS		
ACTIVITY	**HAZARD**	**CONTROLS**
A. Sample screening	A1. Radiation/Contamination	A1. Use disposable gloves and protective clothing when screening samples known or suspected to contain high activity levels. A2. Minimize sample contact. A3. Label sample in accordance with procedures. A4. Monitor personnel and equipment for contamination. A5. Samples that have had the package compromised and have leaked will require monitoring, protective equipment, and notification of the Laboratory Manager.

Section 5.0

Instrumentation

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Section 5.1 – General Information

Purpose

To describe the general approach for calibration and operational check-out of survey instruments.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Detector
- ✓ Portable instrument
- ✓ Cable
- ✓ Record forms
- ✓ Check sources

Calibration

Instruments to be used for quantitative measurements are source calibrated, and the initial check-out performed, prior to each specific site survey (or every six months when used for an extended period for a single site) to determine necessary correction factors and to establish operating parameters and acceptable operating criteria.

Exception: The Pressurized Ionization Chamber (PIC) is calibrated by the manufacturer biennially (when in use) and when the unit is not operating within established parameters.

Calibration is to be performed when possible, with standards traceable to the National Institute of Standards and Technology (NIST) or other industry recognized standards organizations

Originals of calibration records are to be maintained electronically at the Oak Ridge facilities. However, copies must accompany instruments to the survey location.

Instruments used only for qualitative scanning or screening purposes are to have an operational check-out performed prior to each specific site survey.

Instruments are calibrated and/or checked out as an instrument/detector combination and are to be used in that combination for survey activities.

If the site has multiple containments, a weighted efficiency may be required. Refer to the *Multi-Point and Weighted Calibration Efficiency* protocol for additional guidance.

Threshold values are determined based on manufacturer specifications and/or determination of specific characteristics and response. The values listed apply only to the instrument/detector combination referenced.

All equipment associated with instrument and detector operations (e.g., gas tubing, flow meters, regulators, etc.) shall be checked to assure proper working order of the complete survey system. Audio output is to be checked for consistent response with associated headphones and any necessary adapters in place.

Operational Check-Out

This procedure applies to all field survey instruments.

Operational check-out is to be performed daily prior to the use of a survey instrument, after completion of measurements and/or scanning for the day, any time the performance of the instrument is questionable, and at mid-day when feasible. Check-out is also performed as a quality control function according to requirements as described in Section 7 of the *IEAV Quality Program Manual*.

1) Attach the detector to the instrument with the appropriate cable.

2) Turn the instrument on and check batteries. Replace, if necessary.

3) Adjust the threshold (if applicable) and high voltage settings to predetermined values.

4) Background operational parameters will be established for each instrument/detector combination used for quantitative radiation measurements. (If not, refer to Section 4.4 for methodology).

   For instrumentation used for quantitative measurement of surface activity levels, determine and record the background count rate and compare to the control chart.

For instrumentation used for qualitative scanning or exposure rate measurements, determine and record the background count rate or exposure/dose rate. Compare to previous response limits.

5) Place the appropriate check source in contact with the designated location on the detector. Determine and record the count rate on the Instrument Operational Check-Out Form (Figure B-1 or equivalent) and compare to the established response limits.

6) Turn the audible output on to assure its operation.

7) Changes in source responses or background rate, exceeding established acceptable limits must be reconciled before the instrument can be used for data collection.

Section 5.2 – Electronic Calibration of Ratemeters

Purpose

To describe the procedure for calibration of ratemeters.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Portable ratemeter: Model PRM-6, Eberline Instrument Corporation; Model 12, Ludlum Instrument Corporation, Model 2221, Ludlum Instrument Corporation; or equivalent. **NOTE**: The Model PRM-6 or Model 12 ratemeters require an electronic calibration be performed prior to initiating surveys at a new site (and every six months for on-going work) while a Model 2221 requires electronic calibration biannually.

- ✓ Pulser: Model 500, Ludlum Instrument Corporation, or equivalent
  NOTE: The pulsers are calibrated when new and annually thereafter.

- ✓ Cable: MHV-C; or other connectors, as applicable.

- ✓ Record forms

Electronic Set-Up

1) Turn ratemeter on and check batteries, following the instructions below:

   Model PRM-6 and Model 12: Turn the instrument selector switch to BATT. Note condition of batteries on the analog scale. If the reading falls below the acceptable range shown on the meter face, replace the batteries.

   Model 2221: Turn the instrument on. Depress battery button. A digital display reading less than 5.6 volts indicates battery power is marginal and batteries should be replaced.

2) Turn the ratemeter off and connect to the pulser.

3) Turn the pulser on.

4) Set the pulse amplitude to 50 mV and the amplitude adjustment knob to ≥10 on the analog scale.

5) Turn the ratemeter on HV setting. Check instrument voltage reading and pulser voltage reading. (If a difference of 50 V or greater is noted, remove the instrument from service). Record both readings on the Electronic Calibration Record Form (Figure B-2 or equivalent).

6) Set the multiplier knob to the 1K scale.

7) Set pulse rate to 400,000 pulses/min using the multiplier adjustment knobs.

8) Set ratemeter to x1,000 (1K) scale. Record reading.

9) If necessary adjust the 1K potentiometer (pot) inside the ratemeter to bring reading to 400,000 cpm. Record adjusted response.

10) Decrease the pulse rate to 40,000 pulses/min by setting the multiplier knob to the 100 scale.

11) Set ratemeter to the x100 scale. Record reading.

12) If necessary, adjust the x100 pot inside the ratemeter to bring reading to 40,000 cpm. Record adjusted response.

13) Decrease the pulse rate to 4,000 pulses/min by setting the multiplier knob to the 10 scale.

14) Set the ratemeter to the x10 scale.

15) If necessary, adjust the x10 pot inside the ratemeter to bring reading to 4,000 cpm. Record adjusted response.

16) Decrease the pulse rate to 400 pulses/min by setting the multiplier knob to the 1 scale.

17) Set the ratemeter to the x1 scale. Record reading.

18) If necessary, adjust the x1 pot inside the ratemeter, to bring reading to 400 cpm. Record adjusted response.

19) Set ratemeter to x1000 (1K) scale.

20) Set the multiplier knob to the 1K scale.

21) Set pulse rate to 200,000 pulses/min using the multiplier knobs. Record reading.

22) If necessary, adjust the x1,000 (1K) pot inside the ratemeter to bring readings to 200,000 cpm. Record adjusted response.

23) Repeat steps 10-18 for 20,000 pulses/min, 2,000 pulses/min, and 200 pulses/min. Decrease the pulse rate scale first, followed by the ratemeter scale.

24) Verify the initial ratemeter readings for 400,000 pulses/min through 400 pulses/min to ensure calibration stability. If stability is not achieved, remove the instrument from service.

25) Turn off ratemeter and pulse generator and disconnect the cables.

Section 5.3 – Gamma Scintillation Detector Operational Check-Out

Purpose

To describe the procedure for operational check-out of gamma scintillation detectors.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure.

List of Equipment

- ✓ Portable ratemeter: Model PRM-6, Eberline Instrument Corporation; Model 12 or Model 2221, Ludlum Instrument Corporation; or equivalent.
- ✓ Sodium iodide (NaI) detector: Model 489-55, Victoreen Instrument Co.; Model SPA-3 or Model PG-2, Eberline Instrument Corporation; or equivalent.
- ✓ Cable: MHV-MHV; or other connectors, as applicable.
- ✓ Record forms.
- ✓ Check source.

Instrument/Detector Assembly, Operating Voltage Determination

1) Turn ratemeter off to attach the scintillation detector. Turn ratemeter back on. **NOTE**: The Model PRM-6 or Model 12 ratemeters require an electronic calibration be performed prior to initiating surveys at a new site (and every six months for on-going work) while a Model 2221 requires electronic calibration biannually. (Refer to Section 5.2)
2) Note condition of batteries on the analog scale for the PRM-6 and Model 12 or depress the BATT button on the 2221. If the reading falls below the acceptable range shown on the meter face (PRM-6 and Model 12) or 5.6 volts on the 2221 digital readout, replace the batteries. Adjust the threshold setting to 10 mV as follows:
   - **PRM-6:** There is no setting required

- **Model 12:** The discriminator setting may be checked as follows: Open **CAL** cover. With the meter turned on, depress the **HV** button and adjust the **HV** screw beneath the **CAL** cover until the analog meter reads approximately 500 volts. Turn meter off. Connect meter to a NaI detector. Turn meter on then place a gamma check source on the detector. Slowly increase HV until count rates become steady. Adjust **DIS** screw by turning clockwise until count rate rapidly rises from the steady state. Reverse **DIS** screw until count rates return to prior level. Turn two additional counter-clockwise rotations. This will be an approximate setting of 10 mV.
- **Ludlum 2221:** Open **CALIBRATION** cover, depress **THR** button, and adjust **THR** screw under **CALIBRATION** cover until 100 shows on the digital readout.

The operating voltage for individual gamma scintillation detectors are determined based on the characteristics of a plateau curve. Curves are constructed when a new detector is received to establish the general operating voltage once a year for a specific detector/ratemeter or ratemeter-scaler combination, or immediately prior to use for a new combination and after major repairs to a detector. The annual paired combination curves are kept on file in the instrument room and/or maintained electronically. Curves for new project specific combinations are kept in the project-specific file. Two gamma sources are used in determining the operating voltage of the 489-55 and SPA-3 detectors, Co-60 and Cs-137. The PG-2 will use Am-241 and Cs-137.

1) Turn the high voltage down below 500 V. On the 2221, this is done by depressing the **HV** button and adjusting the **HV** screw beneath the **CALIBRATION** cover, the high voltage will be read directly from the digital readout. On the Model 12, the high voltage setting may be approximated by reading off the analog scale while depressing the HV button or connected to the pulsar and the HV setting read off the high voltage scale on the pulsar. The high voltage adjustment screw, **HV**, is beneath the **CAL** cover.

2) Place the detector on one of the two gamma sources with sufficient activity to generate 20,000 counts per minute once the operating voltage is reached. Ensure that the gamma source that is not in use is maintained a sufficient distance away from the detector undergoing plateau curve determination so as not to result in extraneous counts. If there are no counts being registered, slowly increase the high voltage until counts begin to register.

3) The speaker unit may now be turned off.

4) Accumulate counts for 0.5 minute on each source.

5) Record voltage setting and count rate on the Voltage Plateau Determination Form or equivalent.

6) Increase voltage to next higher even multiple of 25 V.

7) Accumulate counts for 0.5 minute and record voltage and count rate.

8) Repeat steps 6 and 7 until the count rate begins to increase rapidly with increased voltage. Do not increase the voltage into the continuous discharge range as damage to the instrument/detector may result. When the count rates between voltage increases begin to stabilize, collect and record 0.5 minute background count rates in addition to the two gamma source counts.

9) Review the results of the count rate vs. voltage. There will be a distinct voltage range over which there is little increase in count rate. This voltage range is called the plateau region of the detector and will typically be a narrow region of 50 to 100 volts. Some detectors will have a broader plateau.

10) Compare the mid-points of the voltage range between the Co-60 and Cs-137 and the background response. Select the overlapping voltage point where count rates are stable between the Cs-137 and Co-60 source responses and the background response as the operating voltage. Adjust the instrument voltage to this setting. (The operating voltage typically ranges between 700 and 1100 volts, dependent upon the age of the detector.)

    Record the predetermined operating voltage and threshold on the Electronic Calibration Record form and the Instrument Operational Checkout form (Figures B-2 and B-1 or equivalent).

Operational Check-Out

1) Determine the background count average with the ratemeter set to slow response.

    – **PRM-6**: rotate the response knob, counterclockwise to the stop.
    – **Model 12/Model 2221**: set the response switch to "S".

2) Record the average count rate on the first data line of the Instrument Operational Check-out Form (Figure B-1 or equivalent).

3) Determine the acceptable background response limits by setting the ratemeter to fast response:

    – **PRM-6**: rotate the response knob clockwise to the stop.
    – **Model 12/Model 2221**: set the response switch to "F".

4) For instruments with an electronic display (Model 2221) perform 10 one-minute counts. Calculate the average counts and the ± 2σ and 3σ ranges. For instruments without an electronic display (Model 12 and PRM-6), record the actual lowest and highest values observed on the analog display. Record response data on the Instrument Operational Check-out Form (Figure B-1 or equivalent).

NOTE: The referenced forms are to accompany the instrument to the field survey site.

Check-Source Reproducibility Determination

1) Position a gamma check source (e.g., Co-60, Cs-137) on the detector and accumulate the count for one minute for an instrument with an electronic display. For an instrument without an electronic display determine the average check source count rate. The check source used should provide a minimum count rate of 10,000 cpm. However, lower activity check sources may be used at the discretion of the Project Leader. Record all information on the Calibration Data Form (Figure B-4 or equivalent).

NOTE: This same check source is to accompany the calibrated instrument to the field survey site.

2) For instruments with an electronic display, remove the detector from the source and reposition the detector and source and repeat the count for a total of 10 times.

3) For instruments without an electronic display, determine the ± 10% variation of the average check source count rate as the source response limits. Otherwise, calculate average value of the ten count rates and the 3σ deviation. The 3σ value must be ≤ 10% of the mean. If it is not, the detector must be removed from service until repairs can be made. Record the values at the bottom of the Instrument Operational Check-out form (Form B-1 or equivalent). If it is not, the detector must be removed from service until repairs can be made.

4) Calculate 5% of the mean. If the 3σ value is less than 5% of the mean, use ± 5% of the mean as the acceptable detector check source response range. If the 3σ value is between 5% and 10% of the mean, use the actual ± 3σ values as the acceptable detector check source response range.

5) Prepare an Instrument Operational Check-out Form (Figure B-1 or equivalent). Enter the average check source count rate, the average background count rate (from the control chart), instrument efficiency (ε_i), and the count times on the first data line. Also, record the acceptable

response limits established for the check source and the background parameters.

NOTE: The referenced forms and check source accompany the instrument to the survey site.

Site Operational Check-Out

1) When initially checking out equipment on site at the start of each workday, midday (when feasible), and at end of the work day, perform a one minute **background count**. Record the count rate on the Instrument Operational Check-out Form (Figure B-1 or equivalent) and compare the results to the response limits.

2) If the site background response checks fall outside the accepted limits established at calibration, **site-specific backgrounds** used for instrumentation operational check-out will be required.

   To **establish a new site background**, perform 10 one-minute background measurements. Calculate the average value and 2σ and 3σ deviation, and allowable range. Record the new background average and response limits.

3) Additionally, when initially checking out equipment on site, at the beginning of each work day, midday (if site logistics permit), and end of the work day, **source response** should also be evaluated. Place the check source at the designated detector position and perform a one minute count. Record the count rate on the Instrument Operational Check-out Form and compare the result to the established response limits.

4) A result outside of the established response limit must be evaluated. New **site-specific check source response limits** may be established in accordance with the Check-Source Reproducibility Determination procedure described in the section above if environmental factors are determined to be the cause of the response shift. Otherwise, remove the instrument/detector from service until repairs can be made.

Section 5.4 – Alpha Scintillation Detector Calibration and Operational Check-Out

Purpose

To describe the procedure for calibration and operational check-out of alpha scintillation detectors.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Portable ratemeter: Model PRS-1 (Rascal), Eberline Instrument Corporation; Model 2221, Ludlum Instrument Corporation; or equivalent.
- ✓ Alpha detector: Model AC3-7, Eberline Instrument Corporation; or equivalent.
- ✓ Cable: CP1-CP1; C-CP1; or other connectors, as applicable.
- ✓ Record forms.
- ✓ Calibration sources.
- ✓ Check source.

Instrument/Detector Assembly and Electronic Set-up

1) Attach the alpha detector to a portable ratemeter-scaler.
2) Check the battery condition for the appropriate instrument/detectors.

   PRS-1/AC3-7: Turn the instrument to the HV position. Note condition of battery as indicated by digital display. Press the "LIGHT" switch. If the "BATT OK" legend does not remain displayed, battery power is marginal and batteries should be replaced.

   2221/AC3-7: Turn the instrument on. Depress battery button. A digital display reading less than 5.6 volts indicates battery power is marginal and batteries should be replaced.

Ensure the operating voltage is set correctly. Refer to the most recent plateau curve determined for the instrument or construct a new curve according to the steps listed in next section of this procedure entitled "Operating Voltage Determination".

3) Adjust the threshold setting accordingly for the following instrument/ detector combinations:

   PRS-1/AC3-7 = 2.0 (20 mv)

   Ludlum 2221/AC3-7 = 100 (10 mv)

4) The window toggle switch should be set to "out", except for special instances as specified by project requirements. In this case, refer to the instrument operating manual or other technical documents for specific guidance on settings for windowed operation.

5) Turn on instrument audio and direct detector face to a source of light to check for "light leaks". Light leaks are indicated by saturation of instrument due to high count rate. Repair or replace detector face as necessary.

Operating Voltage Determination

The operating voltage is determined based on the characteristics of a plateau curve. Curves are constructed once a year, after major repairs to a detector, and when a new detector is received. These curves are kept on file in the instrument room and/or maintained electronically.

1) Place the detector on one of the alpha calibration sources having a 2π surface emission rate greater than 25,000 cpm.

2) Turn the high voltage down, then gradually increase voltage until the meter begins to register counts.

3) The speaker unit may now be turned off.

4) Accumulate counts for 0.5 minute.

5) Record voltage setting and count rate.

6) Increase voltage to next higher even multiple of 50 V.

7) Accumulate counts for 0.5 minute and record voltage and count rate.

8) Repeat steps 6 and 7 until the count rate begins to increase rapidly with increased voltage. Do not increase the voltage into the continuous discharge range as damage to the instrument/detector may result.

9) Prepare a chart of count rate vs. voltage. This chart should consist of a relatively flat section where there is little increase in count rate over a voltage range of up to several hundred volts. This voltage range is called the plateau region of the detector.

10) Select a voltage in the midpoint to 3/4 of the plateau region as the operating voltage and indicate the value on the graph. Adjust the instrument voltage to this setting. (This operating voltage typically ranges between 950 and 1250 volts.)

11) Record the predetermined operating voltage and threshold on the Calibration Form (Figure B-4 or equivalent).

Calibration Background Determination

1) Determine the detector background count for 1 minute.

2) If the background is between the $\pm 2\sigma$ acceptance limits of the established instrument/detector control chart average background, proceed with calibration.

3) If the background value is between the 2σ and 3σ investigation limits perform two more one minute background measurements.

4) If both counts are within the 2σ limits, continue calibration. If the initial background measurement is outside of the $\pm 3\sigma$ limits, perform three additional one minute background measurements.

5) If at least two out of the three additional measurements fall within the 2σ limits and the third measurement is less than the 3σ limit, proceed with calibration.

6) Record the background and response limits (Figure B-4 or equivalent).

7) If the above conditions are not met, then the instrument/detector combination must be removed from service until repairs can be made or the combination is evaluated for changes in instrument operational parameters or other factors. Establishment of a new control chart will be required following any repair or modifications with the potential to affect the background range.

8) Site specific and construction material-specific backgrounds will be determined in the field, as required to address project objectives. Refer to the section entitled "Operational Check-Out and Construction Material-Specific Backgrounds" within this procedure for details.

Efficiency Determination

1) Select an alpha calibration source. The source selected should be a large-area source—larger than the physical detector area—which will provide a minimum accumulation of 10,000 gross counts (C_{s+b}) during the count interval. The typical count interval with available calibration sources is one minute. Longer count times may be necessary, dependent upon calibration source activity.

2) Place the detector on the calibration source and accumulate the count.

3) Record the source identification number, source gross count rate (R_{s+b}) and the 2π surface emission rate, $q_{2\pi}$ (in cpm) from the source calibration certificate on the Calibration Data Form (Figure B-4 or equivalent).

   NOTE: The $q_{2\pi}$ is the 2π emission rate of the calibration source that is subtended by the physical detector area—i.e. determine fraction of total source emission rate that corresponds to physical area of detector as follows:

$$q_{2\pi,sc} = q_{2\pi} \times \frac{Physical\ Detector\ Area\ (cm^2)}{Calibration\ Source\ Area\ (cm^2)}$$

   This correction is only performed when the calibration source area is larger than the detector physical area.

4) If a calibration source smaller than the detector physical area is used, reverse the detector position and repeat the count.

5) Subtract the average control chart background count rate, R_b, from the calibration source gross count rate (R_{s+b} - R_b).

6) Calculate the instrument efficiency (ε_i), for both detector/source arrangements, (average the instrument efficiency obtained from the two measurements if a small-area source was used) and round the result to two significant figures. (The instrument efficiency (ε_i) for an AC3-7 typically ranges 30 to 40%).

$$\varepsilon_i = \frac{R_{s+b} - R_b}{q_{2\pi,sc}}$$

7) Record all information on the Calibration Data Form (Figure B-4 or equivalent).

Check-Source Reproducibility Determination

1) Position an alpha check source (e.g., Th-230) on the detector and accumulate the count for one minute. The check source used should provide a minimum count rate of 10,000 cpm. However, lower activity check sources may be used at the discretion of the Project Leader. Record all information on the Calibration Data Form (Figure B-4 or equivalent).

   NOTE: This same check source is to accompany the calibrated instrument to the field survey site.

2) Remove the detector from the source. Reposition the detector and source and repeat the count for a total of 10 times.

3) Calculate average value of the ten count rates and the 3σ deviation. The 3σ value must be ≤ 10% of the mean. If it is not, the detector must be removed from service until repairs can be made.

4) Calculate 5% of the mean. If the 3σ value is less than 5% of the mean, use ± 5% of the mean as the acceptable detector check source response range. If the 3σ value is between 5% and 10% of the mean, use the actual ± 3σ values as the acceptable detector check source response range.

5) Prepare an Instrument Operational Check-out Form (Figure B-1 or equivalent). Enter the average check source count rate, the average background count rate (from the control chart), instrument efficiency (ε_i), and the count times on the first data line. Also, record the acceptable response limits established for the check source and the background parameters.

   NOTE: This form accompanies the instrument to the survey site.

Operational Check-Out and Construction Material-Specific Backgrounds (see also Section 5.1)

1) When initially checking out equipment on site at the start of each workday, midday (when feasible), and at end of the work day, perform a one minute **background count**. Record the count rate on the Instrument Operational Check-out Form (Figure B-1 or equivalent) and compare the results to the response limits.

2) If the site background response checks fall outside the accepted limits established at calibration, **site-specific backgrounds** used for instrumentation operational check-out will be required.

   To **establish a new site background**, perform 10 one-minute background measurements. Calculate the average value and 2σ and 3σ deviation, and allowable range. Record the new background average and response limits.

3) Additionally, when initially checking out equipment on site, at the beginning of each work day, midday (if site logistics permit), and end of the work day, **source response** should also be evaluated. Place the check source at the designated detector position and perform a one minute count. Record the count rate on the Instrument Operational Check-out Form and compare the result to the established response limits.

4) A result outside of the established response limit must be evaluated. New **site-specific check source response limits** may be established in accordance with the Check-Source Reproducibility Determination procedure described in the section above if environmental factors are determined to be the cause of the response shift. Otherwise, remove the instrument/detector from service until repairs can be made.

5) **Construction material-specific backgrounds** (e.g. concrete, steel, wood, tile, etc.), for use in MDC and surface activity calculations (Section 7.3), will be established at the site for each group of construction materials encountered that exhibit comparable background levels. Material-specific backgrounds will be determined in a site area unaffected by radioactive material use but of similar construction.

   Place the detector in contact with the surface of interest and accumulate counts for one minute (or other count interval, matching sample measurement count interval). Repeat for a total of 10 measurements at different locations on the same material type to account for spatial variability. Calculate and record (Figure B 5 or equivalent) the average background count rate.

   At a minimum, one of each type of instrument/detector combination (e.g. Ludlum 2221 ratemeter-scalers coupled with AC3 7 scintillation detectors) used for quantitative surface activity measurements will be used at the site to acquire these construction material specific backgrounds. The Site Coordinator determines the applicability of the background values to other identical instrument/detector combinations used at the site.

MDC Determination

Calculate and record the minimum detectable concentration (MDC) using the following formula:

$$MDC = \frac{3 + (4.65\sqrt{B})}{T \times \varepsilon_{Tot} \times G}$$

where:

MDC = minimum detectable concentration level in disintegrations/minute/100 cm^2

B = background (total counts) in time interval, T
(construction material-specific background may be used)

T = count time (min) to be used for field measurements

ε_{Tot} = total efficiency = $\frac{counts}{disintegration}$ = ε_i x ε_s

ε_i = instrument efficiency

ε_s = source efficiency (unless otherwise determined: $\boldsymbol{\varepsilon_s}$ **= 0.25** for alpha

G = geometry = $\frac{Physical\ Detector\ Area\ cm^2}{100}$

NOTE: AC3-7 physical detector area = **74 cm^2**

The above formula calculates the activity level in dpm/100 cm^2 which can be detected at the 95% confidence level.

Compare this value to the site guidelines to determine adequate sensitivity of the instrumentation. An MDC that is less than 50% of the applicable criteria is desirable.

Section 5.5 – GM Detector Calibration and Operational Check-Out

Purpose

To describe the procedure for calibration and operational check-out of GM detectors.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Portable ratemeter-scaler: Model PRS-1 (Rascal), Eberline Instrument Corporation; Model 2221, Ludlum Instrument Corporation; or equivalent.
- ✓ GM detector: Model HP-260 (GM "Pancake"); or equivalent.

  NOTE: The HP 260 detector face may be covered with a thin layer of tracing paper to provide a total thickness of 7 mg/cm^2 which will increase the degree of protection of the detector face from accidental puncture and contamination and shield alpha radiation contributions. If a shield is to be used, all calibration and operational check-out procedures should be performed with the shield in place.
- ✓ Cable: CP1-BNC; C-BNC; or other connectors, as applicable.
- ✓ Record forms.
- ✓ Calibration sources.
- ✓ Check source.

Instrument/Detector Assembly and Electronic Set-up

1) Attach the GM detector to a portable ratemeter-scaler.
2) Check the battery condition for the appropriate instrument/detectors.

   PRS-1/HP-260: Turn the instrument to the HV position. Note condition of battery as indicated by digital display. Press the "LIGHT" switch. If the "BATT OK" legend does not remain displayed, then battery power is marginal and batteries should be replaced.

2221/HP-260: Turn the instrument on. Depress battery button. A digital display reading less than 5.6 volts indicates battery power is marginal and batteries should be replaced.

3) Adjust the threshold setting accordingly for the following instrument/ detector combinations:

   PRS-1/HP-260 = 5.0 (50 mv)

   Ludlum 2221/HP-260 = 500 (50 mv)

4) The window toggle switch should be set to "out", except for special instances as specified by project requirements. In this case, refer to the instrument operating manual or other technical documents for specific guidance on settings for windowed operation.

5) Adjust the high voltage to 900 volts.

Calibration Background Determination

1) Determine the detector background count for 1 minute.

2) If the background is between the $\pm$ 2σ acceptance limits of the established instrument/detector control chart average background, proceed with calibration.

3) If the background value is between the 2σ and 3σ investigation limits perform two more one minute background measurements.

4) If both counts are within the 2σ limits, continue calibration. If the initial background measurement is outside of the $\pm$ 3σ limits, perform three additional one minute background measurements.

5) If at least two out of the three additional measurements fall within the 2σ limits and the third measurement is less than the 3σ limit, proceed with calibration.

6) Record the background and response limits (Figure B-4 or equivalent).

7) If the above conditions are not met, then the instrument/detector combination must be removed from service until repairs can be made or the combination is evaluated for changes in instrument operational parameters or other factors. Establishment of a new control chart will be required following any repair or modifications with the potential to affect the background range.

8) Site specific and construction material-specific backgrounds will be determined in the field, as required to address project objectives. Refer to the section entitled "Operational Check-Out and Construction Material-Specific Backgrounds" within this procedure for details.

Efficiency Determination

1) Select a beta calibration source with energies representative of site contaminant(s). The source selected should be a large-area source—larger than the physical detector area—which will provide a minimum accumulation of 10,000 gross counts (C_{s+b}) during the count interval. The typical count interval with available calibration sources is one minute. Longer count times may be necessary, dependent upon calibration source activity. The activity for SrY-90 and Tl-204 calibration sources require decay correction prior to use.

2) Place the detector on the calibration source and accumulate the count.

3) Record the source identification number, source gross count rate (R_{s+b}) and the 2π surface emission rate, $q_{2\pi}$ (in cpm) from the source calibration certificate on the Calibration Data Form (Figure B-4 or equivalent).

   NOTE: The $q_{2\pi}$ is the 2π emission rate of the calibration source that is subtended by the physical detector area—i.e. determine fraction of total source emission rate that corresponds to physical area of detector as follows:

$$q_{2\pi,sc} = q_{2\pi} \times \frac{Physical\ Detector\ Area\ (cm^2)}{Calibration\ Source\ Area\ (cm^2)}$$

   This correction is only performed when the calibration source area is larger than the detector physical area.

4) Subtract the average control chart background count rate, R_b, from the calibration source gross count rate (R_{s+b} - R_b).

5) Calculate the instrument efficiency (ε_i), and round the result to two significant figures. (The instrument efficiency (ε_i) for an HP-260 typically ranges 10 to 50% and is dependent upon source energies).

$$\varepsilon_i = \frac{R_{s+b} - R_b}{q_{2\pi,sc}}$$

6) Record all information on the Calibration Data Form (Figure B-4 or equivalent).

Check-Source Reproducibility Determination

1) Position a beta check source (e.g., Co-60, Sr-90) on the detector. Accumulate the count for one minute. The check source used should provide a minimum count rate of 10,000 cpm. However, lower activity check sources may be used at the discretion of the Project Leader. Record all information on the Calibration Data Form (Figure B-4 or equivalent).

   NOTE: This same check source is to accompany the calibrated instrument to the field survey site.

2) Remove the detector from the source. Reposition the detector and source and repeat the count for a total of 10 times.

3) Calculate the average value of the ten count rates and the 3σ deviation. The 3σ value must be ≤ 10% of the mean. If it is not, the detector must be removed from service until repairs can be made.

4) Calculate 5% of the mean. If the 3σ value is less than 5% of the mean, use ± 5% of the mean as the acceptable detector check source response range. If the 3σ value is between 5% and 10% of the mean, use the actual ± 3σ values as the acceptable detector check source response range.

5) Prepare an Instrument Operational Check-out Form (Figure B-1 or equivalent). Enter the average check source count rate, the average background count rate (from the control chart), instrument efficiency (ε_i), and the count times on the first data line. Also, record the acceptable response limits established for the check source and the background parameters.

   NOTE: This form accompanies the instrument to the survey site.

Operational Check-Out and Construction Material-Specific Backgrounds (see also Section 5.1)

1) When initially checking out equipment on site at the start of each workday, midday (when feasible), and at end of the work day, perform a one minute **background count**. Record the count rate on the Instrument Operational Check-out Form and compare the results to the response limits.

2) If the site background response checks fall outside the accepted limits established at calibration, **site-specific backgrounds** used for instrumentation operational check-out will be required.

To **establish a new site background**, perform 10 one-minute background measurements. Calculate the average value and 2σ and 3σ deviation, and allowable range. Record the new background average and response limits (Figure B-1 or equivalent).

3) Additionally, when initially checking out equipment on site, at the beginning of each work day, midday (if site logistics permit), and end of the work day, **source response** should also be evaluated. Place the check source at the designated detector position and perform a one minute count. Record the count rate on the Instrument Operational Check-out Form and compare the result to the established response limits.

4) A result outside of the established response limit must be evaluated. New **site-specific check source response limits** may be established in accordance with the Check-Source Reproducibility Determination procedure described in the section above if environmental factors are determined to be the cause of the response shift. Otherwise, remove the instrument/detector from service until repairs can be made.

5) **Construction material-specific backgrounds** (e.g. concrete, steel, wood, tile, etc.), for use in MDC and surface activity calculations (Section 7.4), will be established at the site for each group of construction materials encountered that exhibit comparable background levels. Material-specific backgrounds will be determined in a site area unaffected by radioactive material use but of similar construction.

   Place the detector in contact with the surface of interest and accumulate counts for one minute (or other count interval, matching sample measurement count interval). Repeat for a total of 10 measurements at different locations on the same material type to account for spatial variability. Calculate and record (Figure B 5 or equivalent) the average background count rate.

   At a minimum, one of each type of instrument/detector combination (e.g. Ludlum 2221 ratemeter-scalers coupled with AC3-7 scintillation detectors) used for quantitative surface activity measurements will be used at the site to acquire these construction material specific backgrounds. The Site Coordinator determines the applicability of the background values to other identical instrument/detector combinations used at the site.

6) **Optional**: When shielded and unshielded measurements in the survey area are required (refer to Section 7.4), perform the above series of 10 measurements both with and without a minimum

3/8" thick plexiglass shield. Calculate individually and record the shielded and unshielded reference material background count rates. Determine the construction (reference) material background count rate with the ambient background level removed as follows:

$$R_{rm} = R_u - R_s$$

where:

R_{rm} = reference material background count rate (ambient background subtracted out)

R_u = unshielded (gross) background count rate

R_s = shielded background count rate

MDC Determination

Calculate and record the minimum detectable concentration (MDC) using the following formula:

$$MDC = \frac{3 + (4.65\sqrt{B})}{T \times \varepsilon_{Tot} \times G}$$

where:

MDC = minimum detectable concentration level in disintegrations/minute/100 cm^2

B = background (total counts) in time interval, T
(construction material-specific background may be used)

T = count time (min) to be used for field measurements

ε_{Tot} = total efficiency = $\frac{counts}{disintegration}$ = ε_i x ε_s

ε_i = instrument efficiency

ε_s = source efficiency (unless otherwise determined):

ε_s = 0.5 for β_{max} >400 keV (e.g., SrY-90)

ε_s = 0.25 for β_{max} <400 keV (e.g., Tc-99, Tl-204)

$$G = \text{geometry} = \frac{Physical\ Detector\ Area\ cm^2}{100}$$

NOTE: HP-260 physical detector area = **20 cm^2**

The above formula calculates the activity level in dpm/100 cm^2 which can be detected at the 95% confidence level.

Compare this value to the site guidelines to determine adequate sensitivity of the instrumentation. An MDC that is less than 50% of the applicable criteria is desirable.

Section 5.6 – Proportional Detector Calibration and Operational Check-Out

Purpose

To describe the procedure for calibration and operational check-out of proportional detectors.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Portable ratemeter-scaler: Model 2221, Ludlum Instrument Corporation; or equivalent.
- ✓ Proportional detector: Model 43-68, Ludlum Instrument Corporation; or equivalent.
- ✓ Cable: C-C; or other connectors, as applicable.
- ✓ Record forms.
- ✓ Calibration sources.
- ✓ Check source.

Instrument/Detector Assembly, Electronic Set-up, and Detector Purging

1) Purge detector as follows (applies to gas proportional detector set-up to operate in the alpha, alpha+beta, or beta-only mode):

   a. Attach P-10 gas supply and detector outlet hoses to flow meters. Refer to operating manual.

   b. Turn on main bottle valve and adjust flow rate to approximately 100 cc/min. Allow to purge for 5 minutes. Reduce flow to approximately 40 cc/min and continue purging for 20 minutes.

2) Attach the detector to a portable ratemeter-scaler.

3) Turn the instrument on and check the battery strength by depressing the battery button. A digital display reading of less than 5.6 volts indicates battery power is marginal and batteries should be replaced.

4) Adjust the threshold setting to 50 (5.0 mV). (This value applies to both the alpha and the alpha-beta modes).

5) The window toggle switch should be set to "out", except for special instances as specified by project requirements. In those cases, refer to the instrument operating manual or other technical documents for specific guidance on settings for windowed operation.

6) Ensure that the operating voltage is set correctly for the appropriate detection mode (alpha, alpha+beta, or beta-only). Refer to the most recently constructed plateau curve determined for the instrument or construct a new curve according to the steps listed in next section of this procedure entitled "Operating Voltage Determination".

7) Perform a purge check by placing the appropriate check source (alpha or beta) for the detection mode and taking a one-minute count. Record on the Calibration Data Form (Figure B-4 or equivalent).

   Wait approximately one minute and then collect a second one-minute count. If the two count rates vary by greater than ± 10%, continue purging and checking until the rate is stabilized. If the second count is within ± 10% of first count, unit is adequately purged and ready for use.

8) Disconnect the out flow line and replace with a tubeless coupling to allow for continuous venting of the system. Continuous flow is required during calibration.

   NOTE: Unit may be used in the static mode if a good seal can be established. The length of time a static purge can be maintained varies for individual detectors. To operate in static mode disconnect both hoses from the detector. Begin checking source response as soon as the background count rate begins to drop off. If a decline of approximately 10% or more is noted, the system must be repurged.

Operating Voltage Determination

The operating voltage is determined based on the characteristics of a plateau curve. Curves are constructed once a year, after major repairs to a detector, and when a new detector is received. These curves are kept on file in the instrument room and/or maintained electronically.

NOTE: Using an alpha and a beta source simultaneously is the preferable methodology because it provides a more accurate representation of the proportional region plateau curve. However, a plateau region can also be determined independently for alpha or beta by placing the appropriate source and adjusting the starting point accordingly. Alternatively, , when the detector is used in the beta-only mode, a thicker mylar window (3.8 mg/cm^2 rather than the standard 0.8 mg/cm^2) may be used to eliminate alpha contributions. All calibration procedures are then performed with the thicker window installed on the detector.

1) Place the detector on a jig with a double source configuration. Select an alpha and/or a beta calibration source each having a 2π surface emission rate of greater than 25,000 cpm.
2) Turn the high voltage all the way down and then gradually increase the voltage until the meter just begins to register counts. The speaker unit may now be turned off.
3) Accumulate counts for 0.5 minute.
4) Record voltage setting and count rate on a worksheet or on a spreadsheet with charting capabilities.
5) Increase voltage to next higher even multiple of 50 V.
6) Accumulate counts for 0.5 minute and record voltage and count rate.
7) Repeat steps 6 and 7 until the count rate begins to increase rapidly with increased voltage (this usually occurs at some point above 1800 volts and indicates continuous discharge – do not increase the voltage past this point. Remove the detector from the sources and turn the voltage down to the desired detection mode).
8) Prepare a graph of count rate vs. voltage. This graph should consist of two relatively flat sections where there is little increase in count rate over a voltage range of up to several hundred volts. This voltage range is called the plateau region for the detector.
9) Select an operating voltage between the midpoint and 3/4 for each of the plateau regions and indicate the value on the graph. (This operating voltage typically ranges between 1000 and 1300 volts for alpha and 1650 and 1800 volts for beta.).

   NOTE: Problems have been noted when using proportional detectors in high altitude areas. It may be necessary to establish the operating voltage and to perform calibration on-site. Special arrangements must be made through the Survey Projects Manager to remove the calibration sources from the facility and with the receiving department at the destination site.

Background Determination

Adjust the operating voltage for the appropriate detection mode (alpha, alpha+beta, or beta-only) and record the value on the Calibration Data Form (Figure B-4 or equivalent).

1) Determine the detector background count for 1 minute.

2) If the background is between the ± 2σ acceptance limits of the established instrument/detector control chart average background, proceed with calibration.

3) If the background value is between the 2σ and 3σ investigation limits perform two more one minute background measurements.

4) If both counts are within the 2σ limits, continue calibration. If the initial background measurement is outside of the ± 3σ limits, perform three additional one minute background measurements.

5) If at least two out of the three additional measurements fall within the 2σ limits and the third measurement is less than the 3σ limit, proceed with calibration.

6) Record the background and response limits (Figure B-4 or equivalent).

7) If the above conditions are not met, then the instrument/detector combination must be removed from service until repairs can be made or the combination is evaluated for changes in instrument operational parameters or other factors. Establishment of a new control chart will be required following any repair or modifications with the potential to affect the background range.

8) Site specific and construction material-specific backgrounds will be determined in the field, as required to address project objectives. Refer to the section entitled "Operational Check-Out and Construction Material-Specific Backgrounds" within this procedure for details.

Efficiency Determination

1) Select a calibration source for the appropriate detection mode (e.g., Th-230, for alpha detection; Tc-99, for beta detection. Project requirements and/or calibration source availability will generally be the determining factors for selection).

   The source selected should be a large-area source—larger than the physical detector area—which will provide a minimum accumulation of 10,000 gross counts (C_{s+b}) during the count interval. Some sources may require a decay correction to determine the actual activity. The typical count interval with available calibration sources is one minute. Longer count times may be necessary, dependent upon calibration source activity.

2) Place the detector over the calibration source (place the source at the approximate center of the detector if using a small-area source) and accumulate the count.

3) Record the source identification number, source gross count rate (R_{s+b}) and the 2π surface emission rate, $q_{2\pi}$ (in cpm) from the source calibration certificate on the Calibration Data Form (Figure B-4 or equivalent).

NOTE: The $q_{2\pi}$ is the 2π emission rate of the calibration source that is subtended by the physical detector area—i.e. determine fraction of total source emission rate that corresponds to physical area of detector as follows:

$$q_{2\pi,sc} = q_{2\pi} \times \frac{Physical\ Detector\ Area\ (cm^2)}{Calibration\ Source\ Area\ (cm^2)}$$

This correction is only performed when the calibration source area is larger than the detector physical area.

4) Subtract the average control chart background count rate, R_b, from the calibration source gross count rate (R_{s+b} - R_b).

5) Calculate the instrument efficiency (ε_i), and round the result to two significant figures. (The instrument efficiency (ε_i) for a 43-68 typically ranges 36 to 44% for alpha mode and 10% to 60% for beta modes).

$$\varepsilon_i = \frac{R_{s+b} - R_b}{q_{2\pi,sc}}$$

6) Record all information on the Calibration Data Form (Figure B-4 or equivalent).

Calibration Check-Source Reproducibility Determination

1) Position the appropriate check source (e.g., Th-230 for alpha, Sr-90 for beta) at the front portion of the detector or use a jig. Accumulate the count for one minute. The check source used should provide a minimum count rate of 10,000 cpm. However, lower activity check sources may be used at the discretion of the Project Leader. Record

all information on the Calibration Data Form (Figure B-4 or equivalent).

NOTE: This same check source is to accompany the calibrated instrument to the field survey site.

2) Remove the detector from the source. Reposition the detector and source and repeat the count for a total of 10 times.

3) Calculate the average value of the ten count rates and the 3σ deviation. The 3σ value must be ≤ 10% of the mean. If it is not, the detector must be removed from service until repairs can be made.

4) Calculate 5% of the mean. If the 3σ value is less than 5% of the mean, use ± 5% of the mean as the acceptable detector check source response range. If the 3σ value is between 5% and 10% of the mean, use the actual ± 3σ values as the acceptable detector check source response range. Record all information (Figure B-4 or equivalent).

5) Prepare an Instrument Operational Check-out Form (Figure B-1 or equivalent). Enter the average check source count rate, the average background count rate (from the control chart), instrument efficiency (ε_i), and the count times on the first data line. Also, record the acceptable response limits established for the check source and the background parameters.

NOTE: This form accompanies the instrument to the survey site.

Operational Check-Out and Construction Material-Specific Backgrounds (see also Section 5.1)

1) When initially checking out equipment on site at the start of each workday, midday (when feasible), and at end of the work day, perform a one minute **background count**. Record the count rate on the Instrument Operational Check-out Form and compare the results to the response limits.

2) If the site background response checks fall outside the accepted limits established at calibration, **site-specific backgrounds** used for instrumentation operational check-out will be required. To **establish a new site background**, perform 10-one minute background measurements. Calculate the average value and 2σ and 3σ deviation, and allowable range. Record the new background average and response limits (Figure B-1 or equivalent).

3) Additionally, when initially checking out equipment on site, at the beginning of each work day, midday (if site logistics permit), and end of the work day,

source response should also be evaluated. Place the check source at the designated detector position and perform a one minute count. Record the count rate on the Instrument Operational Check-out Form and compare the result to the established response limits.

4) A result outside of the established response limit must be evaluated. New **site-specific check source response limits** may be established in accordance with the Check-Source Reproducibility Determination procedure described in the section above if environmental factors are determined to be the cause of the response shift. Otherwise, remove the instrument/detector from service until repairs can be made.

5) **Construction material-specific backgrounds** (e.g. concrete, steel, wood, tile, etc.), as required to address project objectives for use in MDC and surface activity calculations (Section 7.3), may be established at the site for each group of construction materials encountered that exhibit comparable background levels. Material-specific backgrounds will be determined in a site area unaffected by radioactive material use but of similar construction.

   Place the detector in contact with the surface of interest and accumulate counts for one minute (or other count interval, matching sample measurement count interval). Repeat for a total of 10 measurements at different locations on the same material type to account for spatial variability. Calculate and record (Figure B 5 or equivalent) the average background count rate.

6) **Optional**: When shielded and unshielded measurements in the survey area are required (refer to Section 7.4), perform the above series of 10 measurements both with and without a minimum 3/8" thick plexiglass shield. Calculate individually and record the shielded and unshielded reference material background count rates. Determine the construction (reference) material background count rate with the ambient background level removed as follows:

$$R_{rm} = R_u - R_s$$

where:
R_{rm} = reference material background count rate (ambient background subtracted out)
R_u = unshielded (gross) background count rate

R_s = shielded background count rate

At a minimum, one of each type of instrument/detector combination (e.g. Ludlum 2221 ratemeter-scalers coupled with 43-68 gas proportional detectors) used for quantitative surface activity measurements will be used at the site to acquire these construction material-specific backgrounds. The Site Coordinator determines the applicability of the background values to other identical instrument/detector combinations used at the site.

MDC Determination

Calculate and record the minimum detectable concentration (MDC) using the following formula:

$$MDC = \frac{3 + (4.65\sqrt{B})}{T \times \varepsilon_{Tot} \times G}$$

where:

MDC = minimum detectable concentration level in disintegrations/minute/100 cm^2

B = background (total counts) in time interval, T
(construction material-specific background may be used)

T = count time (min) to be used for field measurements

ε_{Tot} = total efficiency = $\frac{counts}{disintegration}$ = ε_i x ε_s

ε_i = instrument efficiency

ε_s = source efficiency (unless otherwise determined)

ε_s = 0.25 for alpha emitters

ε_s = 0.25 for β_{max} <400 keV (e.g., Tc-99, Tl-204)

ε_s = 0.5 for β_{max} >400 keV (e.g., SrY-90)

G = geometry = $\frac{Physical\ Detector\ Area\ cm^2}{100}$

NOTE: 43-68 physical detector area = **126 cm^2**

The above formula calculates the activity level in dpm/100 cm^2 which can be detected at the 95% confidence level.

Compare this value to the site guidelines to determine adequate sensitivity of the instrumentation. An MDC that is less than 50% of the applicable criteria is desirable.

Section 5.7 – Alpha/Beta Scintillation Detector Calibration and Operational Check-Out

Purpose

To describe the procedure for calibration and operational check-out of a scintillation detector for simultaneous alpha/beta counting.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Portable ratemeter-scaler: Model 2223, Ludlum Instrument Corporation; or equivalent.
- ✓ Alpha/beta scintillation detector: Model 43-89, Ludlum Instrument Corporation; or equivalent.
- ✓ Ludlum Model 500 Pulser, or equivalent
- ✓ Cable: C-C; or other connectors, as applicable.
- ✓ Record forms.
- ✓ Calibration sources.
- ✓ Check source.

Instrument/Detector Assembly and Electronic Set-up

1) Switch the knob to the $\alpha+\beta$ position.

2) Press the BAT Button. (**NOTE**: The needle should register above the Battery OK portion of the scale. If not, replace batteries.)

3) Check voltage. Operating voltage should be approximately 750 V. See voltage posting on selected detector.

Operating Voltage Determination

1) Connect the Model 2223 ratemeter-scaler to the pulser.

2) Switch the 2223 to the β position. Adjust the beta threshold (βT) for 4 mV and the window (βW) for 60 mV. The pulser counts should be detected on the 2223 ratemeter-scaler above 4 ± 1 mV and should shut off above 60 mV.

3) Move the channel selector switch to the alpha position. Adjust the pulser for a 120 mV pulse output and vary the alpha threshold (αT) control until counts are detected on the ratemeter-scaler.

4) Depress the HV switch and adjust the HV potentiometer for 0.4 to 0.5V on the 0-1.5 scale. Connect the scintillator and switch to the beta only position. Place an alpha source (e.g. Th-230 or Pu-239) on the detector face.

5) Slowly increase the HV potentiometer to observe an increase, then decrease, and increase again in count as the voltage is increased. Decrease the voltage until the ratemeter is in the "dip" of the observed count rate versus HV plot just performed. Depress the HV switch and note the setting.

6) Plot the voltage against the count rate in 25 volt increments, 50 volts each side of the HV reading found in the above step (e.g., HV setting for count "dip" in the above step should be approximately 675 volts; start the plot at 625 volts and increase in 25 volt steps until 725 volts is reached). This should be done for an alpha source (e.g. Th-230 or Pu-239), a beta source (e.g. Tl-204 or SrY-90), and background counts for both alpha and beta channel positions.

7) Find the optimum operating voltage from the plot which gives the greatest alpha and beta source efficiency while maintaining no greater than the maximum acceptable level of "cross talk" between channels.

   Beta to alpha "crosstalk" should not exceed 3%. Alpha to beta "crosstalk" should not exceed 10% for Th-230 or Pu-239.

   Select the desired count channel display and proceed with calibration.

Calibration Background Determination

1) Turn ratemeter-scaler off. Attach scintillation detector and turn ratemeter-scaler back on and adjust to $\alpha+\beta$ position.

2) Determine the detector background count for 1 minute.

3) If the background is between the $\pm$ 2σ acceptance limits of the established instrument/detector control chart average background, proceed with calibration.

4) If the background value is between the 2σ and 3σ investigation limits, perform two more one minute background measurements.

5) If both counts are within the 2σ limits, continue calibration. If the initial background measurement is outside of the $\pm$ 3σ limits, perform three additional one minute background measurements.

6) If at least two out of the three additional measurements fall within the 2σ limits and the third measurement is less than the 3σ limit, proceed with calibration.

7) Record the background and response limits (Figure B-4 or equivalent).

8) If the above conditions are not met, then the instrument/detector combination must be removed from service until repairs can be made or the combination is evaluated for changes in instrument operational parameters or other factors. Establishment of a new control chart will then be required following any repair or modifications with the potential to affect the background range.

9) Site specific and construction material-specific backgrounds will be determined in the field, as required to address project objectives. Refer to the section entitled "Operational Check-Out and Construction Material-Specific Backgrounds" within this procedure for details.

Efficiency Determination

1) Select an alpha calibration source. The source selected should be a large-area source—larger than the physical detector area—which will provide a minimum accumulation of 10,000 gross counts (C_{s+b}) during the count interval. The typical count interval with available calibration sources is one minute. Longer count times may be necessary, dependent upon calibration source activity.

2) Place the detector over the alpha calibration source (place the source at the approximate center of the detector is using a small-area source) and accumulate the count. Record the source identification number, source gross count rate (R_{s+b}) and the 2π surface emission rate, $q_{2\pi}$ (in cpm) from the source calibration certificate on the Calibration Data Form (Figure B-4 or equivalent).

   NOTE: The $q_{2\pi}$ is the 2π emission rate of the calibration source that is subtended by the physical detector area—i.e. determine fraction of total source emission rate that corresponds to physical area of detector as follows:

$$q_{2\pi,sc} = q_{2\pi} \times \frac{Physical\ Detector\ Area\ (cm^2)}{Calibration\ Source\ Area\ (cm^2)}$$

   This correction is only performed when the calibration source area is larger than the detector physical area.

3) Subtract the α average control chart background count rate, R_b, from the calibration source gross count rate (R_{s+b} - R_b) in the alpha channel.

4) Calculate the instrument efficiency (ε_i), and round the result to two significant figures. (The instrument efficiency (ε_i) for a 43-89 typically ranges 20 to 40%).

$$\varepsilon_i = \frac{R_{s+b} - R_b}{q_{2\pi,sc}}$$

   Record all information on the Calibration Data Form (Figure B-4 or equivalent).

5) Select a beta calibration source with energies representative of the site contaminant(s). The source selected should be a larger-area source–larger than the physical detector area–which will provide a minimum accumulation of 10,000 gross counts during the count interval. The typical count interval with available calibration sources is one minute. Longer count times may be necessary, dependent upon calibration source activity.

6) Place the detector over the beta calibration source (place the source at the approximate center of the detector if using a small-area source) and accumulate the count. Record the source, its associated identification number, the source gross count rate (R_{s+b}) in the β

channel and the 2π surface emission rate, $q_{2\pi}$ (in cpm) from the source calibration certificate. Calculate the percent "cross-talk" as follows:

$$\%\ Cross-Talk = \frac{Net\ (\alpha+\beta)\ cpm}{Net\ (\alpha+\beta)\ cpm}$$

7) Subtract the average control chart background count rate, R_b from the calibration source gross count rates (R_{s+b} - R_b) in the beta channel.

NOTE: The $q_{2\pi}$ is the 2π emission rate of the calibration source that is subtended by the physical detector area—i.e. determine fraction of total source emission rate that corresponds to physical area of detector as follows:

$$q_{2\pi,sc} = q_{2\pi} \times \frac{Physical\ Detector\ Area\ (cm^2)}{Calibration\ Source\ Area\ (cm^2)}$$

This correction is only performed when the calibration source area is larger than the detector physical area.

8) Calculate the instrument efficiency (ε_i), and round the result to two significant figures. (The instrument efficiency (ε_i) for a 43-89 typically ranges 5 to 20%).

$$\varepsilon_i = \frac{R_{s+b} - R_b}{q_{2\pi,sc}}$$

Record all information on the Calibration Data Form (Figure B-4 or equivalent).

Calibration Check-Source Reproducibility Determination

1) Position an alpha check source on the detector or use a jig. Accumulate the count for one minute. The check source used should provide a minimum count rate of 10,000 cpm. However, lower activity check sources may be used at the discretion of the Project Leader. Record the source position, count rate, and time.

NOTE: This same check source is to accompany the calibrated instrument to the field survey site.

2) Remove the detector from the source. Reposition the detector and source and repeat the count for a total of 10 times.

3) Calculate the average value of the ten count rates and the 3σ deviation. The 3σ value must be ≤ 10% of the mean. If it is not, the detector must be removed from service until repairs can be made.

4) Calculate 5% of the mean. If the 3σ value is less than 5% of the mean, use ± 5% of the mean as the acceptable detector check source response range. If the 3σ value is between 5% and 10% of the mean, use the actual ± 3σ values as the acceptable detector check source response range.

5) Prepare an Instrument Operational Check-out Form (Figure B-1 or equivalent). Enter the average check source count rate, the average background count rate (from the control chart), instrument efficiency (ε_i), and the count times on the first data line. Also, record the acceptable response limits established for the check source and the background parameters.

   NOTE: This form accompanies the instrument to the survey site.

6) Position a beta check source on the detector or use a jig. Accumulate the count for one minute. The check source used should provide a minimum count rate of 10,000 cpm. However, lower activity check sources may be used at the discretion of the Project Leader. Record the source position, count rate, and time.

   NOTE: This same check source is to accompany the calibrated instrument to the field survey site.

7) Remove the detector from the source. Reposition the detector and source and repeat the count for a total of 10 times.

8) Calculate the average value of the ten count rates and the 3σ deviation. The 3σ value must be ≤ 10% of the mean. If it is not, the detector must be removed from service until repairs can be made.

9) Calculate 5% of the mean. If the 3σ value is less than 5% of the mean, use ± 5% of the mean as the acceptable detector check source response range. If the 3σ value is between 5% and 10% of the mean, use the actual ± 3σ values as the acceptable detector check source response range.

10) Prepare an Instrument Operational Check-out Form (Figure B-1 or equivalent). Enter the average check source count rate, the average background count rate (from the control chart), instrument efficiency (ε_i), and the count times on the first data line. Also, record the acceptable response limits established for the check source and the background parameters.

   NOTE: This form accompanies the instrument to the survey site.

Operational Check-Out and Construction Material-Specific Backgrounds

1) When initially checking out equipment on site at the start of each workday, midday (when feasible), and at end of the work day, perform a one minute **background count**. Record the count rate on the Instrument Operational Check-out Form and compare the results to the response limits.

2) If the site background response checks fall outside the accepted limits established at calibration, **site-specific backgrounds** used for instrumentation operational check-out will be required. To **establish a new site background**, perform 10 one-minute background measurements. Calculate the average value and 2σ and 3σ deviation, and allowable range. Record the new background average and response limits (Figure B-1 or equivalent).

3) Additionally, when initially checking out equipment on site, at the beginning of each work day, midday (if site logistics permit), and end of the work day, **source response** should also be evaluated. Place the check source at the designated detector position and perform a one minute count. Record the count rate on the Instrument Operational Check-out Form and compare the result to the established response limits.

4) A result outside of the established response limit must be evaluated. New **site-specific check source response limits** may be established in accordance with the Check-Source Reproducibility Determination procedure described in the section above if environmental factors are determined to be the cause of the response shift. Otherwise, remove the instrument/detector from service until repairs can be made.

5) **Construction material-specific backgrounds** (e.g. concrete, steel, wood, tile, etc.), as required to address project objectives for use in MDC and surface activity calculations (Sections 7.3 and 7.4), may be established at the site for each group of construction materials encountered that exhibit comparable background levels. Material-specific backgrounds will be determined in a site area unaffected by radioactive material use but of similar construction.

Place the detector in contact with the surface of interest and accumulate counts for one minute (or other count interval, matching sample measurement count interval). Repeat for a total of 10 measurements at different locations on the same material type to account for spatial variability. Calculate and record (Figure B 5 or equivalent) the average background count rate.

6) **Optional**: When shielded and unshielded measurements in the survey area are required (refer to Section 7.4), perform the above series of 10 measurements both with and without a minimum 3/8" thick plexiglass shield. Calculate individually and record the shielded and unshielded reference material background count rates. Determine the construction (reference) material background count rate with the ambient background level removed as follows:

$$R_{rm} = R_u - R_s$$

where:
R_{rm} = reference material background count rate (ambient background subtracted out)

R_u = unshielded (gross) background count rate

R_s = shielded background count rate

At a minimum, one of each type of instrument/detector combination (e.g. Ludlum 2223 ratemeter-scalers coupled with 43-89 scintillation detectors) used for quantitative surface activity measurements will be used at the site to acquire these construction material-specific backgrounds. The Site Coordinator determines the applicability of the background values to other identical instrument/detector combinations used at the site.

MDC Determination

Calculate and record the minimum detectable concentration (MDC) using the following formula:

$$MDC = \frac{3 + (4.65\sqrt{B})}{T \times \varepsilon_{Tot} \times G}$$

where:

MDC = minimum detectable concentration level in disintegrations/minute/100 cm^2

B = background (total counts) in time interval, T
(construction material-specific background may be used)

T = count time (min) to be used for field measurements

ε_{Tot} = total efficiency = $\frac{counts}{disintegration}$ = ε_i x ε_s

ε_i = instrument efficiency

ε_s = source efficiency (as below, unless otherwise determined)

ε_s = 0.25 for alpha

ε_s = 0.25 for β_{max} <400 keV (e.g., Tc-99, Tl-204)

ε_s = 0.5 for β_{max} >400 keV (e.g., SrY-90)

G = geometry = $\frac{Physical\ Detector\ Area\ cm^2}{100}$

NOTE: 43-89 physical detector area = **117 cm^2**

The above formula calculates the activity level in dpm/100 cm^2 which can be detected at the 95% confidence level.

Compare this value to the site guidelines to determine adequate sensitivity of the instrumentation. An MDC that is less than 50% of the applicable criteria is desirable.

Section 5.8 – Pressurized Ionization Chamber (PIC) Calibration and Operational Check-Out

Purpose

To describe the procedure for operational check-out of the Model RSS-112 pressurized ionization chambers (PIC).

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

General

The pressurized ionization chamber (PIC) is used for exposure rate measurements and, at times, as a secondary standard for cross calibration of other gamma measuring instruments. Calibration of this equipment is therefore done by the manufacturer. Recalibration is done biennially or any time repairs of the instrument are required.

Immediately following calibration by the manufacturer, the initial operational check-out is performed on the PIC according to steps outlined later in this procedure.

List of Equipment

- ✓ Pressurized ionization chamber (PIC).
- ✓ Electronics package.
- ✓ Connecting cables.
- ✓ Tripod.
- ✓ Check source.
- ✓ Record forms.

Initial Operational Check-Out

1) Place the pressurized ion chamber (PIC) on the tripod and extend the legs of the tripod to where the center of the detection chamber is 1 m above the floor.

2) Connect the PIC to the electronics package using the cable supplied with the unit.

3) Turn on the Power switch (located on the rear) to the zero position.

4) Within about 3 seconds the LCD should display the MAIN MENU.

   In about 12-15 seconds the CURRENT DATA/DOSE INTEGRATOR screen should appear on the LCD display. If this screen does not appear, press on the display arrows to return to the MAIN MENU. Select CURRENT DATA, select DATA STATUS, and the current DATA/DOSE INTEGRATOR screen should appear on the LCD.

   The reading must be <1 μR/h for acceptable operation.

   NOTE: If the reading is not <1 μR/h, adjust the setting using the potentiometer located on the PIC near the cable connection.

5) Set the PIC at the desired location and allow the unit to stabilize. The unit should be stabilized within five minutes.

6) Perform the battery check as follows:

   a. Exit CURRENT DATA mode by pressing any arrow key under the LCD display.
   b. Select UNIT TEST from the MAIN MENU.
   c. Select MORE until SYSTEM STATUS appears.
   d. Select SYSTEM STATUS.
   e. Record the battery status as a percentage of the measured versus the known, i.e., 309V/300V=1.03%, on PIC FORM or equivalent.
   f. Select CONT.
   g. Select MORE until EXIT appears.
   h. Select EXIT to return to MAIN MENU.

   NOTE: It takes about 3-10 seconds to automatically return to CURRENT DATA/DOSE INTEGRATOR screen.

7) Perform a background as follows:

   a. Turn the switch (located on the rear) to READ. Allow about 1 minute to stabilize.

   b. Press RESET INTEGRATOR key to start Dose Integrator

   c. Acquire background readings until a stable average μR/h is obtained. Record the average reading as displayed on the CURRENT DATA/DOSE INTEGRATOR screen in μR/h on the first data line of the PIC/Bicron Tracking Form, Figure B-24, or equivalent.

   NOTE: New Data becomes available every five seconds on the CURRENT DATA/DOSE INTEGRATOR screen in μR/h.

8) Perform a source check as follows:

   a. Obtain Cs-137 check source and place on the top center of the PIC.

   b. Allow about one minute to stabilize.

   c. Press RESET INTEGRATOR key.

   d. Acquire check source readings until a stable average μR/h is obtained. Record the average reading displayed on the CURRENT DATA/DOSE INTEGRATOR screen in μR/h on the PIC Tracking Form (Figure B-24 or equivalent). Establish response limits as ±10% of the net value and record on the same form.

9) To display DOSE RATE in large number display do the following:

   a. Exit CURRENT DATA screen to MAIN MENU by pressing arrow under EXIT.

   b. Select CURRENT DATA.

   c. Select DOSE RATE and the large number display will come on with date and time. Return to the MAIN MENU before shutting down the PIC.

   d. To return to the MAIN MENU, press any arrow.

   e. Select CURRENT DATA

   f. Select DATA STATUS

   NOTE: An asterisk displayed in the upper right corner indicates either a radiation alarm or system failure (i.e., low battery [12V], etc.).If there is reason to believe it is an actual alarm, evacuate the area immediately and proceed to a safe distance. If it indicates system failure, view the error message by checking the SYSTEM STATUS as described in step 6 above.

Pre-survey Check-Out

1) Transfer the acceptable net check source response limits from the PIC Tracking Form to the PIC Field Check-out Form (Figure B-6 or equivalent).

2) After the initial operational check-out is performed according to the procedure outlined above, record the background and check source readings on the PIC Field Check-out Form.

3) Compare the net check source exposure rate to the acceptable net response limit. If the response is within the response limits, record the information for the gross and net measurements on the first line of the PIC Field Check-out Form (the line marked "ORISE DATA"), and on the next available line of the PIC Tracking Form. If the net exposure rate does not fall within the acceptable range limits, remove the PIC from service until repairs can be made.

   NOTE: The PIC Field Check-out Form accompanies the instrument to the field survey site.

Field Operational Check-Out

When initially checking out equipment on site, at the start of each work day, midday, and the end of the work day, perform background and source check response according to steps 7 and 8 described earlier in the initial set-up procedure. Record the count rate on the PIC/Bicron Field Check-out Form (Figure B-6 or equivalent) and compare the results to the response limits. If outside these limits, it may be necessary to re-establish site-specific limits. If the check-out continues to be outside of control limits, take the instrument out of service until further evaluation. Ensure that the detector is checked out under actual use conditions.

Section 5.9 – Bicron Micro-rem Meter Check-Out

Purpose

To describe the procedure for operational check-out of the Bicron micro-rem meter and the Bicron extended detector meters. The Bicron micro-rem meter is used for exposure rate measurements and the cross calibration of other gamma measuring instruments. Calibration of this equipment is done on a biennial basis by the manufacturer and/or on a more frequent basis by an ORISE electronics specialist.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure.

List of Equipment

✓ Bicron micro-rem meter or Bicron micro-rem extended detector meter

✓ Check source.

✓ Record forms.

Initial Operational Check-Out

1) Turn the control switch to the batteries (bat) position. The needle reading should be within “bat.ok” region indicated on the scaler. If the reading falls outside the acceptable region replace the batteries.

   NOTE: If the instrument is not responding correctly, (i.e., reproducibility) and the battery response is less than or equal to 150 on the analog scale, then replace batteries.

2) Turn the control switch to high voltage (HV). The needle reading should fall into the predetermined “HV ok” region.

   NOTE: If the reading is outside predetermined “HV ok” region, remove the instrument from service until repairs can be made.

3) Turn the control switch to one of 5 different positions (x0.1 through x1000). Typically, the switch position for background determinations should be at x0.1.

4) Allow the meter to stabilize for approximately 15 to 30 seconds. Determine the average background rate by collecting 10 instantaneous readings and calculating the average. Record the average background rate on the first data line of the PIC/Bicron Tracking Form (Figure B-24 or equivalent).

5) Record the acceptable background response limits as the actual lowest and highest of the 10 readings obtained for the average background determination on the PIC/Bicron Tracking Form (Figure B-24 or equivalent).

6) Place the instrument-specific gamma check source (stored within the instrument case) at the front of the detector.

   NOTE: It is very important in determining the check source range that the position of the check source to detector be the same each time. For the box type meter (without the extended detector), place the check source at the predetermined location at the front of the instrument. The location is marked with an x within a circle, ⊗. For the extended detector meter, keep the protective cap on, and place the check source at the center of the detector by gently depressing the protective cap with the source.

7) Determine the average gross dose rate by collecting 10 instantaneous readings and calculating the average. Determine the average net dose rate by subtracting the average background rate. Record both the gross and net dose rate average values on the PIC/Bicron Tracking Form (Figure B-24 or equivalent). Also, determine and record the ± 10% variation of the check source count rate as the source response limits. Record the source check number on the Tracking Form.

Pre-Survey Check-Out

1) Transfer the acceptable background and net check source response limits from the PIC/Bicron Tracking Form to the PIC/Bicon Field Check-Out Form (Figure B-6 or equivalent).

2) Perform operational checks as listed in the previous section of this procedure.

3) Collect 10 instantaneous readings, calculate the average and record the average gross and net dose rates (gross dose rate-background dose rate) on the first data line of the PIC/Bicron Field Check-Out Form and on the next available line of the PIC/Bicron Tracking Form. Compare the check source dose rate to the source response limits.

NOTE: This check source and the PIC/Bicron Field Check-Out Form are to accompany the instrument to the field survey site.

Field Operational Check-Out

Perform background and source check response when initially checking out equipment on site at the start of each work day, at midday, and the end of the work day. Record the count rate on the PIC/Bicron Field Check-Out Form (Figure B-6 or equivalent) and compare the results to the response limits. If outside these limit, it may be necessary to re-establish site-specific limits. If the check-out continues to be outside of control limits, take the instrument out of service until further evaluation. Ensure that the detector is checked out under actual use conditions.

Section 5.10 – Compensated GM Detector Calibration and Operational Check-Out

Purpose

To describe the procedure for calibration and operational check-out for energy compensated GM detectors.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure.

List of Equipment

- ✓ Portable ratemeter-scaler: Model PRS-1 (Rascal); Eberline Instrument Corporation; or equivalent.
- ✓ Energy compensated GM detector: Model HP-270, Eberline Instrument Corporation; or equivalent.
- ✓ Cable: CP1-BNC; or other connectors, as applicable.
- ✓ Calibration source.
- ✓ Check source.
- ✓ Record forms.

Instrument/Detector Assembly and Electronic Set-Up

1) Attach the detector (shield closed) to a portable ratemeter-scaler.
2) Turn on, check batteries, and replace if necessary.
3) Adjust high voltage to 900 V and threshold to 5 (50 mV).
4) Determine background for 5 minutes and calculate background count rate. Record the value on the Calibration Data Form (Figure B-4 or equivalent).

Cross-calibration can be performed; as for gamma scintillation detectors, see page 3 of Section 5.3. Calibration for exposure rates at levels exceeding the capability of the PIC can be performed under the direction of staff health physicists and the ORISE Environmental Safety and Health office. Record information on the Cross Calibration Form (Figure B-3 or equivalent) or the Exposure Rate Calibration Data Form (Figure B-21 or equivalent).

5) Determine check source reproducibility by positioning a gamma check source (Co-60 or Cs-137) on the side of the detector and determine and record the count rate on the Calibration Form (Figure B-4 or equivalent). Repeat 10 times and calculate average and 2σ and 3σ deviation. Record check source range.

   NOTE: Check source and form are to accompany the calibrated instrument to the field survey site.

6) Prepare an Instrument Operational Check-out Form (Figure B-1 or equivalent) entering the background and average check source counting rates on the first data line.

   NOTE: This form accompanies the instrument to the survey site.

7) Daily instrument operational check-out is performed according to Section 5.1.

Section 5.11 – Floor Monitor Check-Out

Purpose

To describe the procedure for check-out of floor monitors.

Responsibilities

• The Site Coordinator is responsible for assuring that this procedure is implemented.

• Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Portable ratemeter-scalers: Model 2221, Ludlum Instrument Corporation; or equivalent.
- ✓ Model 43-37, Ludlum Instrument Company; or equivalent.
- ✓ Floor monitor cart: model 239-1, Ludlum Instrument Company; or equivalent.
- ✓ Cable: C-C; or other connectors, as applicable.
- ✓ Check source.
- ✓ Record forms.

The floor monitor is used only for qualitative determinations and locating areas of surface contamination. It is not used as a measuring device.

Operational Check-Out

1) Attach the detector to the portable ratemeter-scaler.
2) Turn on instrument, check batteries, and replace, if necessary.
3) Set threshold to 100 (10.0 mV).

Set the high voltage to the detector-specific level. The operating voltage is determined based on the characteristics of a plateau curve (refer to page 2 of Section 5.6). These curves are prepared once a year, after major repairs to a detector, and when a new detector is received. Files are kept in the instrument room.

The typical alpha voltage will usually be about 1250V.
The typical alpha-beta voltage will usually be about 1750.

4) Attach P-10 gas supply and detector outlet hoses to flow meters. Refer to operating manual.

5) Turn on main bottle valve and adjust flow rate to approximately 100 cc/min. Allow to purge for 10 minutes.

6) Decrease flow rate to 40-60 cc/min and purge for at least 20 minutes.

7) Place an appropriate check source (alpha or beta) beneath the detector. Note source count rate.

8) Note source count rate 2 minutes later. If count rate varies by greater than ± 10% continue purging and checking until the rate is stabilized. If second count is within ± 10% of first count, unit is adequately purged and ready for use. Record both purge check values on the Instrument Operational Check-out Form (Figure B-1 or equivalent). Record the acceptable check source response range as ± 10% of the second source count. Document floor monitor head configuration and source placement or use jig/spacers to reproduce source-to-detector distance and solid angles for subsequent operational check-outs.

   NOTE: This check source and form are to accompany the instrument to the field survey site.

9) Remove source and record background count rate on the Instrument Operational Check-out Form (Figure B-1 or equivalent). Background response provides indication of detector contamination. Background response also is used to bound both *a priori* and *a posteriori* scan MDCs.

10) Turn on speaker unit and check audible response, with and without headphones connected.

11) When initially checking out equipment on site, at the start of each workday, midday (if site logistics permit for the check source), and end of the workday, perform a one-minute background count followed by a one-minute check source count. Record both values on the Instrument

Operational Check-Out Form (Figure B-1 or equivalent) and compare with acceptable response ranges.

12) If operation in "static" mode is necessary, disconnect hoses from the detector and turn off main gas valve. If continuous flow is to be used, the flow rate may remain at approximately 40 cc/min.

13) Unit should maintain a purge for approximately two hours following purging. Recheck source response about every 15 minutes while operating in static mode. If count rate drops by more than 25%, repurge detector.

    NOTE: Remove the gas tank and detector head from floor monitor before transporting. Appropriate shipping papers must accompany the P-10 gas during transport (see Section 10.0).

Section 5.12 – GM Detector-based Pipe Monitor Calibration and Check-Out

Purpose

To describe the procedure for calibration and operational check-out of GM detector-based pipe monitor used for evaluating internal surfaces of embedded pipe.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Portable ratemeter-scalers: **Three** Model 2221s; Ludlum Instrument Corporation; or equivalent.
- ✓ Pipe Monitor: (ORISE-designed) with three GM "Pancake" detector tubes.
- ✓ Cables: **Three** 50-foot C-BNC; or other connectors, as applicable.
- ✓ Calibration source.
- ✓ Pipe calibration jig, (ORISE-designed), concrete-encased, split stainless steel pipe, or other appropriate pipe geometry that simulates the field-use environment.
- ✓ Check source.
- ✓ Record forms

Instrument/Detector Assembly and Electronic Set-Up

1) Attach each GM detector to a portable ratemeter-scaler.

2) Check battery conditions by turning each of the instruments on. Depress the battery button. A digital display reading less than 5.6 volts indicates battery power is marginal and batteries should be replaced.

3) Set the threshold display for each of the three instruments as follows:
Ludlum 2221/GM detector 500 (50 mV).

4) Adjust the high voltage on each instrument to 900 volts.

Calibration Background Determination

1) Determine the detector background count for 1 minute.

2) If the background is between the ± 2σ acceptance limits of the established instrument/detector control chart average background, proceed with calibration.

3) If the background value is between the 2σ and 3σ investigation limits perform two more one minute background measurements.

4) If both counts are within the 2σ limits, continue calibration. If the initial background measurement is outside of the ± 3σ limits, perform three additional one minute background measurements.

5) If at least two out of the three additional measurements fall within the 2σ limits and the third measurement is less than the 3σ limit, proceed with calibration.

6) Record the background and response limits (Figure B-4 or equivalent).

7) If the above conditions are not met, then the instrument/detector combination must be removed from service until repairs can be made or the combination is evaluated for changes in instrument operational parameters or other factors. Establishment of a new control chart will be required following any repair or modifications with the potential to affect the background range.

8) Site specific and construction material-specific backgrounds will be determined in the field, as required to address project objectives. Refer to the section entitled "Operational Check-Out and Construction Material-Specific Backgrounds" within this procedure for details.

Efficiency Determination

1) Wrap the Tc-99 or other available pipe calibration source around the inside of the appropriate diameter pipe to match the internal diameter of the pipes to be investigated. Pipe calibration geometries larger than 4 inches in diameter may require the source be placed on both the bottom and top of the pipe and an average efficiency calculated. This configuration will require specific notations on the calibration form.

2) This step may be performed with the pipe monitor and source in both a vertical and horizontal configuration dependent upon the configuration of the pipes to be surveyed. Place the detector within the pipe.

When in the horizontal configuration, record which detector is positioned on the bottom of the pipe. Accumulate counts for each detector/instrument combination over a count interval that will provide a minimum accumulation of 10,000 gross counts (C_{s+b}) for each detector. Record the source identification number, source gross count rate (R_{s+b}) for each detector, and 2π surface emission rate, $q_{2\pi}$ (in cpm) from the source calibration certificate on the Pipe Monitor Calibration Data Form (Figure B-25 or equivalent).

For the vertical position, the monitor may be rotated 180^o and a second count performed. The average of these values is then used as the calibration source gross count rate for each detector in the following calculations. Pipe diameters, larger than the source that require top and bottom of the pipe calibration jig, will also require an average efficiency calculation between the two calibration configurations.

NOTE: The $q_{2\pi}$ is the 2π emission rate of the calibration source that is subtended by the physical detector area—i.e. determine fraction of total source emission rate that corresponds to physical area of detector as follows:

$$q_{2\pi,sc} = q_{2\pi} \times \frac{Physical\ Detector\ Area\ (cm^2)}{Calibration\ Source\ Area\ (cm^2)}$$

This correction is performed for the individual detectors. The physical area for the individual detectors is 20 cm^2.

3) For each detector, subtract the respective average control chart background count rate, R_b, for that detector from the calibration source gross count rate (R_{s+b} - R_b).

4) Calculate the instrument efficiency (ε_i), for each detector using the equation below, and round the result to two significant figures. (The instrument efficiency (ε_i) for a GM detector typically ranges from 10 to 50% and is dependent upon source energies and surface to detector distance).

$$\varepsilon_i = \frac{R_{s+b} - R_b}{q_{2\pi,sc}}$$

5) A separate efficiency term may also be calculated for the detector array, dependent upon site-specific requirements and conditions encountered. Calculate the average instrument efficiency (ε_i) for the array using the above equation. In the numerator, substitute the summed calibration

source plus background count rates for each detector (R_{s+b}) and subtract the summed background (R_b) for each detector. The $q_{2\pi,sc}$ in the denominator is calculated using the equation listed above in step 2 and a physical area of the array is equal to **168 cm²**. Larger pipes will require a modification to the array geometry that reflects the array field of view to the area of the pipe.

6) Record all information on the Pipe Detector Calibration Data Form (Figure B-25 or equivalent).

Check Source Reproducibility Determination

1) Position a beta check source (e.g., Co-60, Sr-90) on each of the detectors. Accumulate the count for one minute. The check source used should provide a minimum count rate of 10,000 cpm. However, lower activity check sources may be used at the discretion of the Site Coordinator. Record the source position, count rate, and time.

2) Remove the detector from the source. Reposition the detector and source and repeat the count. Repeat 10 times. Calculate average value and the 3σ deviation. The 3σ value must be ≤ 10% of the mean. If it is not, the detector must be removed from service until repairs can be made. Calculate ± 5% of the mean. If the 3σ is less than 5% of the mean, use ± 5% of the mean as the acceptable detector check source response range. If the 3σ is between 5% and 10% of the mean, use the actual ± 3σ values as the acceptable detector check source response range. Record all information (Figure B-25 or equivalent).

3) **NOTE:** This same check source is to accompany the calibrated instrument to the field survey site.

4) Prepare a Pipe Monitor Operational Check-out Form (Figure B-26 or equivalent). Enter the average check source count rate, the average background count rate (from the control chart), instrument efficiency (ε_i), and the count times on the first data line. Also enter acceptable range limits for the check source and background response (from the control chart).

   NOTE: This form accompanies the instrument to the survey site.

Site Operational Check-Out and Construction Material-Specific Backgrounds (see also Section 5.1)

1) When initially checking out equipment on site at the start of each workday, midday (when feasible), and at end of the work day, perform a one minute **background count**. Record the count rate on the Pipe Monitor Operational Check-Out Form and compare the results to the response limits.

2) If the site background response checks fall outside the accepted limits established at calibration, **site-specific backgrounds** used for instrumentation operational check-out will be required. To **establish a new site background**, perform 10 one-minute background measurements. Calculate the average value and 2σ and 3σ deviation, and allowable range. Record the new background average and response limits (Figure B-1 or equivalent).

3) Additionally, when initially checking out equipment on site, at the beginning of each work day, midday (if site logistics permit), and end of the work day, **source response** should also be evaluated. Place the check source at the designated detector position and perform a one minute count. Record the count rate on the Pipe Monitor Operational Check-out Form and compare the result to the established response limits.

4) A result outside of the established response limit must be evaluated. New **site-specific check source response limits** may be established in accordance with the Check-Source Reproducibility Determination procedure described in the section above if environmental factors are determined to be the cause of the response shift. Otherwise, remove the instrument/detector from service until repairs can be made.

5) If suitable unaffected embedded piping is available on site, establish site-specific backgrounds, for use in MDC and surface activity calculations (refer to Section 7.4). Otherwise, the background will be established at the ORISE facility using the concrete-encase stainless steel pipe calibration jig.

   Place the detector array inside the unaffected embedded piping or calibration jig and accumulate counts for one minute (or other count interval, matching sample measurement count interval). Repeat for a total of 10 measurements at different locations on the same material type to account for spatial variability. Calculate and record (Figure B 5 or equivalent) the average background count rate for each individual detector and for the array (sum of the average individual detector backgrounds).

MDC Determination

Calculate and record the minimum detectable concentration (MDC) using the following formula for each detector individually and the array:

$$MDC = \frac{3 + (4.65\sqrt{B})}{T \times \varepsilon_{Tot} \times G}$$

where:

MDC = minimum detectable concentration level in disintegrations/minute/100 cm²

B = background (total counts) in time interval, T
(construction material-specific background may be used). For individual detector MDC, substitute the individual detector's background count rate. For the array, substitute the summed background count rates of the individual detectors.

T = count time (min) to be used for field measurements

ε_{Tot} = total efficiency = $\frac{counts}{disintegration}$ = ε_i x ε_s

ε_i = instrument efficiency

ε_s = source efficiency (unless otherwise determined)

ε_s = 0.5 for β_{max} >400 keV (e.g., SrY-90)

ε_s = 0.25 for β_{max} <400 keV (e.g., Tc-99, Tl-204)

$$G = \text{geometry} = \frac{Physical\ Detector\ Area\ cm^2}{100}$$

NOTE: Pipe monitor array physical detector area = **168 cm²**
(unless otherwise specified by the Site Coordinator to account for larger pipe diameter field of views greater than 4 inches)

The above formula calculates the activity level in dpm/100 cm^2 which can be detected at the 95% confidence level.

Compare this value to the site guidelines to determine adequate sensitivity of the instrumentation. An MDC that is less than 50% of the applicable criteria is desirable.

Section 5.13 – Global Positioning Systems Set-Up

Purpose

To describe the procedure for setting up global position systems (GPS) for use with radiation detection instrumentation.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure.

List of Equipment

✓ Portable ratemeter: Model 2221 or Model 12, Ludlum Instrument Corporation; or equivalent, **modified with RS-232 data collection capabilities**.

✓ Sodium iodide (NaI) detector: Model 489-55, Victoreen Instrument Co.; Model SPA-3 or Model PG-2, Eberline Instrument Corporation; Bicron Field Instrument for Detection Low Energy Radiation (FIDLER); or equivalent.

✓ Check source.

✓ Trimble GeoXH GPS Pocket PC unit, or equivalent, with Mobile OS and TerraSync software (periodic upgrades may be required).

✓ Cables: C-MHV; or other connectors, as applicable, for ratemeter-detector.

✓ Serial clip and coaxial cable with DB9 (female)/right-angle SMA connectors for connecting ratemeter to handheld Trimble GPS unit.

✓ Carriage-style battery charger for GPS unit (Trimble P/N 53500-00).

✓ Zephyr antennae and range poles, optional.

✓ Stylus (for Pocket PC touch-screen entry).

Pre-Survey Settings

1. Assemble the ratemeter and detector and perform initial calibration and check-out in accordance with Section 5.3.

2. Attach the serial clip to the Trimble GeoXH unit and then connect to the RS-232-enabled ratemeter with a DB9/right-angle SMA coaxial cable. (**NOTE:** Inspection should be performed for visible signs of wear and tear which may cause a loose connection resulting in improper data transfer).

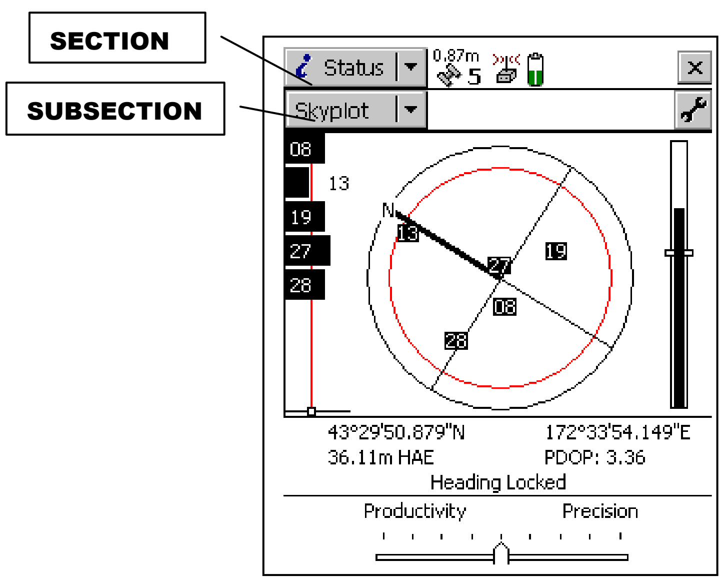
3. Turn the Trimble GeoXH unit on (green button). (If the unit does not turn on, the battery may require charging).

4. Ensure the clock and date settings are correct to prevent correction errors in post-processing.

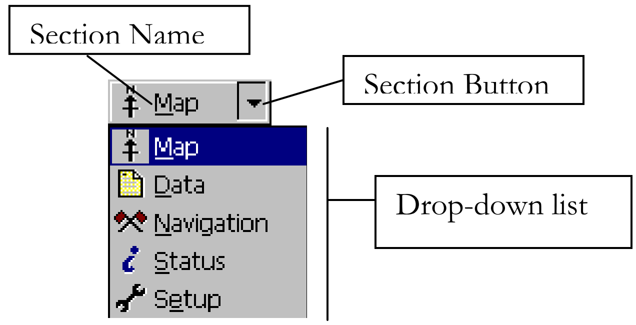
   To reset the clock if incorrect, select "Start" in the operating system display (in the upper left corner), and then select "Settings". From the bottom tabs, select "System" and then the "Clock and Alarms" option. Reset the time and/or calendar date, if necessary. Click OK in the upper right corner when completed and then close the "Settings" menu by tapping the "X" in the upper right corner.

5. Start the TerraSync software by either selecting the **GPS** hyperlink in the lower right corner of the screen <u>or</u> select **Start** from the upper left corner of the screen and then select **TerraSync** from the list provided**.**

6. By default, the opening screen is the Sky Plot screen which shows the satellites available to the GPS receiver. If performing this check indoors, no satellites will be available. A screen-capture image is presented below.



7. The TerraSync software is arranged in the following five sections:



The Section list button shows the section that is currently active. You can move between sections at any time without closing any open forms or screens. To switch to a different section, tap the Section list button and then select the Section you want from the drop-down list.

Each Section has a number of Subsections (see figure on previous page for location of Subsection button) which also contain drop-down lists of relevant functions. Refer to the TerraSync Reference Manual for more detail on the functions of each Section and Subsection.

8. Set the default filename prefix to the project tracking number as follows: Select **Setup** from the Section button and then select **Logging Settings** from the Subsection button. Ensure the settings are as follows unless otherwise determined:

Log Velocity Data:	No
Log H-Star Data:	Auto
Log SuperCorrect Data:	Yes
Antenna Height:	1.000 m
Allow Position Update:	Yes
Confirm End Feature:	No
Filename Prefix:	*"4-digit project task #"*
Between Feature Logging Style:	Time
Between Feature Logging Interval:	1s

9. Verify that the correct instrument is selected as the external sensor as

follows: Select **Setup** from the Section button and then select **External Sensors** in the lower right display. A list of items should be displayed including **Laser**, **2221**, and **model_12**. Checkmark the appropriate list item for the instrumentation to be used. If the listing is different than that described above, the sensor needs to be reset according to the settings described in the table below by clicking on the **Properties** button located to the right of the list item:

Name:	**2221** (or **model_12** as appropriate)	
Communications Port:	COM1: Serial Cable on COM1: (additionally ensure that the non-selected sensor Communications Port is set to "None")	
Baud Rate:	9600	
Data Bits:	8	
Stop Bits:	1	
Parity:	None	
Prefix String:	R (for the 2221)	RM (for the model_12)
Suffix String:	*blank*	
Max Bytes:	*blank*	
Time Out:	0.10 s	
Receive Mode:	Unsolicited	
Point Feature:	All	
Line/Area Feature;	All	
Not in Feature:	All	
Data Destination	Uninterpreted	

10. Ensure the coordinate system is set correctly (the Site Coordinator will have specific information for project requirements).

    Select **Setup** from the Section button and then the **Coordinate System** button located in the lower left of the display. Ensure the **System**, **Datum,** and **Zone** (if required) are set to the correct parameters. In the absence of an established system, it is recommended that a latitude/longitude system be used in a WGS 1984 datum.

Operational Set-Up

NOTE: The following steps are not required if only using the unit to reference sampling locations (Refer to Section 7.8).

1. Select a reference point on the site with good satellite reception to perform operational check-outs. The objectives are to establish that communication between the instrument and the GPS unit is working correctly and that the GPS location accuracy is within expected tolerance (typically, expected to be within 5 meters or less).

2. Similar to the daily check-out of the instrument with a check-source, ensure that the unit is communicating correctly with the instrument as follows:

   a. Turn the instrument on and set the Digital Control toggle switch to **Dig. Rate. (NOTE:** The instrument will not log counts if the toggle switch is set to **Scaler**).

   b. Tap the Section button and pick **Data** from the drop-down list.

   c. Name the file using the Touch Keyboard (located in the lower center screen – tap the up arrow if it is not displayed). The **File Name** text box should already be selected – name the file as follows [do not included parentheses, spaces, or any other separating punctuation]:

      opchk*(2-digit month)(2-digit date)(1st and last initial)*

      (e.g., **opchk1001jd** - indicates data was collected on October 1 by John Doe)

   d. Tap the **Create** button in the upper right corner.

   e. Confirm antenna height default settings by tapping the **OK** button in the dialog box unless determined otherwise.

   f. Tap the Section button and pick **Status** from the drop-down list.

   g. Tap the Subsection button and pick **Sensor** from the drop-down list.

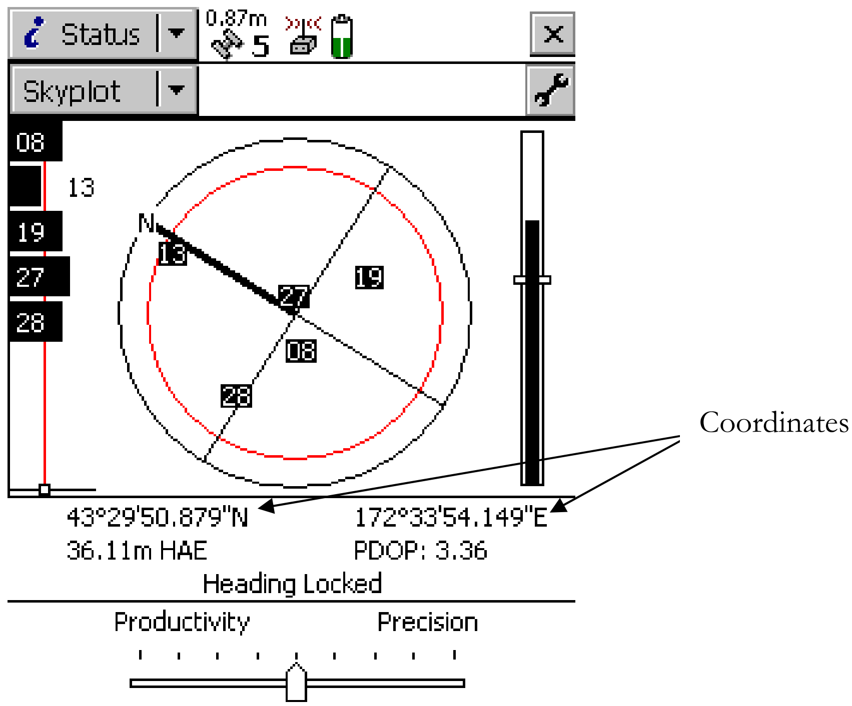
   h. Observe the screen for at least one minute while performing an operational check-out of the instrument with an appropriate check source in accordance with Section 5.3.

      The line labeled **Total Count** should be updating every two seconds (however, data are logged at a one-second frequency) with the number of data points collected (a minimum of 60 should be collected).

      The line labeled **Last String** should match the value on the instrument display (with the exception of leading zeroes and squares representing line-end characters).

i. Record the operational check-out values obtained from the check-source for the instrument combination on the appropriate form. Indicate with a check-mark that the instrument reading matches the **Last String** value displayed.

j. Additionally, record the geographic coordinate for the selected reference point on the check-out form. To view the coordinate, tap the Section button and select **Status** and then from the Subsection button select **Skyplot.** The coordinate will be listed in the bottom center of the display.



k. To terminate the data collection session, tap the Section button and pick **Data** from the drop-down list.

l. Tap the **Close** button. Tap **OK** when prompted for verification to close the file.

Section 5.14 — Field Instrument for Detection of Low-Energy Radiation (FIDLER)

Purpose

To describe the process for determining the operating voltage and discriminator settings for the Bicron FIDLER detector.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure.

List of Equipment

- ✓ Portable ratemeter-scaler: Model 2221 Ludlum Instrument Corporation; or equivalent.
- ✓ Multichannel Analyzer (MCA): TracerNorthern TN7200 or equivalent.
- ✓ High voltage power supply: (EGG Ortec).
- ✓ Pulse forming box (ORISE design)
- ✓ FIDLER NaI (Tl) Scintillation Detector: Model G5, Bicron Instrument Corporation; or equivalent.
- ✓ Cable: C-MHV; or other connectors, as applicable.
- ✓ Record forms.
- ✓ Check source.

Electronic Set-Up and Determination of Detector Resolution

1. Assemble MCA to the power supply and MCA to the pulse forming box.
2. Connect the pulse forming box "out" connector (cable) to the direct "input" connection on the MCA. Make sure that the switch near the direct input connection is switched to "direct".
3. Connect the pulse forming box to the FIDLER using a C-MHV cable. Connect the high voltage (HV) input connector to the ORTEC HV power supply.
4. Set the high voltage to 800 volts initially and turn on the power supply and MCA.

5. Set the MCA memory group to 1/2 to acquire data.

6. Using a Cs-137 source accumulate counts for approximately 300 seconds and save the data. The region of interest is the low-energy 32 keV reference peak.

7. Set the memory group to 2/2 for additional data acquisition.

8. Remove the Cs-137 source and replace with an Am-241 source. Accumulate counts and save the data. There are two regions of interest – 14 keV and 59.5 keV – for the Am-241.

9. Overlay the two acquisitions. Recall the Cs-137 and Am-241 acquisition and observe the peaks. There should be three distinct reference peaks as mentioned above in Steps 6 and 8 in the regions of interest for the sources used.

10. If the peaks do not appear separately, increase the voltage in 100 volt increments and recount.

11. When the energy of the radionuclide is visible in the region of interest, this is the most appropriate operating voltage for the detector.

12. Record the voltage on the Instrument Operational Check-Out Form (Figure B-1 or equivalent).

Instrument/Detector Assembly and Electronic Set-Up for Windowed Operation

1. After the operating voltage has been established, disconnect the detector from the pulse forming box and connect to the ratemeter-scaler.

2. Turn the power on. Depress the battery button. A digital display reading of less than 5.6 volts indicates that the battery power is marginal and batteries need to be replaced.

3. Adjust the voltage as determined in the previous section of this procedure for the specific detector.

4. The following steps will determine the appropriate operating threshold. Place the appropriate source beneath the detector. Turn on the speaker and set the audio divide switch on the ratemeter-scaler to 10 for better audible detection.

5. Adjust the threshold setting to approximately 20 mV (200 mV digital display) or lower so that counts are barely registering.

6. Set **the window switch to "in".**
7. Adjust the window setting to 2 mV (digital display is 20).
8. Increase the threshold until the ratemeter-scaler begins to register counts.

   NOTE: The Am-241 has two peaks. The threshold (lower window setting) needs to be set at the beginning of the second peak of 59.5 keV.
9. Record the threshold value on the Instrument Operational Check-Out Form (Figure B-1 or equivalent).
10. Continue to increase the threshold as counts increase to a maximum and beyond until the counts begin to decrease again to a minimum. Note the threshold value (upper window setting).
11. Calculate the difference between the lower and higher threshold values. The difference will be the window setting. Record the window value on Instrument Operational Check-Out Form (Figure B-1 or equivalent).
12. Adjust the window to the determined setting.

Background Determination

1. Adjust the instrument setting to the predetermined operating voltage, threshold and window setting and record the values on the Instrument Operational Check-Out Form.

2. Determine the detector background average count rate by performing 10 one-minute background counts. Calculate the mean and the 2σ and 3σ standard deviation for the response limits. Record the background and response limits on the Instrument Operational Check-Out Form (Figure B-1 or equivalent).

Check Source Reproducibility

1. Select an appropriate gamma check source and position it under the detector. Accumulate the count for one minute. The check source used should provide a minimum count rate of 10,000 cpm. However, lower activity check sources may be used at the discretion of the Site Coordinator. Record all information in the appropriate location on the reverse side of Instrument Operational Check-Out Form (Figure B-1 or equivalent).

   NOTE: This same check source is to accompany the calibrated instrument to the field survey site.

2. Remove the detector from the source. Reposition the detector and source and repeat the count for a total of 10 times.

3. Calculate the average value and the 3σ deviation. The 3σ value must be no more than ± 10% of the mean. If it is not, the instrument/detector combination must be removed from service until repairs can be made.

4. Calculate ± 5% of the mean. If the 3σ is less than 5% of the mean, use ± 5% of the mean as the acceptable check source response range. If the 3σ is between 5% and 10% of the mean, use the actual ± 3σ values as the acceptable detector check source response range. Determine the average check source count rate and record the count rate on the first data line of the record form.

5. Record the average check source count rate and the average background count rate on the Instrument Operational Check-out Form (Figure B-1 or equivalent). Also, record the acceptable response limits established for the check source and the background parameters.

   NOTE: This form accompanies the instrument to the survey site.

Operational Check-Out (see also Section 5.1)

1. When initially checking out equipment on site at the start of each workday, midday, and at end of the work day, perform a one minute **background count**. Record the count rate on the Instrument Operational Check-out Form (Figure B-1 or equivalent) and compare the results to the response limits.

2. If the initial site background response checks fall outside the accepted limits established at calibration, **site-specific backgrounds** used for instrumentation operational check-out will be required.

   To **establish a new site background**, perform 10 one-minute background measurements. Calculate the average value and 2σ and 3σ deviation, and allowable range. Record the new background average and response limits.

3. Additionally, when initially checking out equipment on site, at the beginning of each work day, midday (if site logistics permit), and end of the work day, **source response** shall also be evaluated. Place the check source at the designated detector position and perform a one-minute count. Record the count rate on the Instrument Operational Check-out Form and compare the result to the established response limits.

4. A result outside of the established response limit must be evaluated. New **site-specific check source response limits** may be established in accordance with the Check-Source Reproducibility Determination procedure described in the section above if environmental factors are determined to be the cause of the response shift. Otherwise, remove the instrument/detector from service until repairs can be made.

Section 5.15 – Job Hazard Analysis – Instrument Calibration and Use

Discussion

Job hazards associated with instrument calibration and setup and preparing to mobilize and then demobilizing from a site are minimal. Minor radiation, electrical, and general duty hazards do exist and are presented below together with standard controls.

Calibration Activities

JOB HAZARD ANALYSIS		
ACTIVITY	**HAZARD**	**CONTROL**
A. Gather instruments/detectors from storage shelves	Al. Lifting, some equipment is heavy (PIC)	A1. Use proper lifting techniques.
B. Connect instrument to detector with cable	B1. Mild electrical shock from frayed cables	B1. Inspect cables prior to use. Ensure they are in good condition and replace if defective.
C. Establish power supply or electrically pulse instruments	C1. Mild electrical shock	C1. Ensure all connections are made and correct prior to turning power supply on.
D. Connect P-10 gas supply (gas proportional detector only)	D1. Compressed gas hazards	D1. Ensure tanks are properly secured when stored or in use. Ensure valve cap is secured when carrying cylinders by hand or in transport boxes.
	D2. Lifting cylinder	D2. Use proper lifting techniques.
E. Calibrate and/or source check instrument/detector combinations	E1. Low-level radiation	El. Minimize direct contact with sources. Return sources to storage containers when not in use.

Section 6.0

Site Preparation

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Section 6.1 – Clearing to Provide Access

Purpose

To establish a policy regarding requirements for clearing materials from facilities and open land areas in preparation for gridding and survey measurements and sampling.

Responsibilities

- Removal or relocation of equipment and materials which may entail special precautions to prevent damage or maintain inventory accountability should be performed by the property owner whenever possible.

- Clearing open land of brush and weeds will usually be performed by a professional land clearing organization under subcontract arrangements. However, survey personnel may perform limited minor land clearing activities as required.

- The Site Coordinator is responsible for determining the degree of clearing needed and for supervising onsite clearing activities to assure compliance with conditions of survey plans and subcontract agreements.

- The Survey Projects Manager will prepare or approve the necessary plans, subcontracts, and other documents describing and implementing the clearing operations.

Procedures

The extent of site clearing required in specific areas will be primarily dependent upon the potential for radioactive contamination existing in those areas.

Where the radiological history and/or results of previous surveys do not indicate potential contamination of an area, it may be sufficient to perform only minimum clearing to establish a reference grid system.

Areas where contamination is known to exist or that have a high potential for contamination must be completely cleared to provide access to all surfaces.

Findings as the survey progresses may require that additional clearing be performed.

Clearing includes providing access to potentially contaminated interior surfaces, e.g., drains, ductwork, tanks, pits, and equipment by removal of covers, disassembly, or other means of producing adequate openings.

Open land areas may be cleared by heavy machinery, e.g., bulldozers, bushhogs, and hydroaxes. However care must be exercised to prevent relocation of surface contamination or damage to site features such as drainage ditches, utilities, fences, and buildings.

Minor land clearing may be performed using manually operated equipment such as brushhooks, power saws, knives, and power trimmers.

Brush and weeds should be cut to the minimum practical height, not to exceed 30 cm. Care should be exercised to prevent unnecessary damage to or removal of mature trees.

Section 6.2 – Reference Grid/Coordinate System

Purpose

To provide a procedure for establishing a grid or coordinate system for referencing radiological survey activities.

Responsibilities

- The Site Coordinator is responsible for determining the gridding or geographic coordinate selection requirements and supervising onsite activities to assure compliance with conditions of survey plans and subcontract agreements.
- The Survey Projects Manager will prepare or approve the necessary plans, subcontracts, and other documents describing and implementing gridding operations.

Procedures

Indoor areas and some open land areas may already be gridded or linked to a geographic coordinate system as part of the licensee/contractor's decontamination and decommissioning (D&D) survey activities. Where possible, ORISE surveys will utilize the same systems previously established.

ORISE prefers to use the metric system for gridding measurements. This system will be used, except where the property owner has established an acceptable grid system in English units. Grid dimensions will be determined based on the potential for contamination in the area and must also allow for adequate systematic measurement and sampling points. Typical grid intervals are 1 to 2 meters for building surveys and 5 to 10 meters for open land surveys.

Global Positioning Systems (GPS) may be used in place of Cartesian gridding systems for open land areas. When appropriate, use coordinate systems determined by the licensee or contractor to ensure location comparison accuracy.

In the absence of an established system, it is recommended that a latitude/longitude system be used in a WGS 1984 datum. When establishing an independent coordinate system, use professional judgment and maintain consistency in referencing this system throughout the project.

Building Grid System

The equipment that should be used is listed below:

✓ Measuring tape

✓ Grid markers; masking tape, markers, paint, or chalk

1. Indoor grids not already in place may be established by the ORISE survey team. However, some circumstances may not require that a formal Cartesian gridding system be installed. These would include, but are not limited to, random sampling locations generated with software such as Visual Sample Plan (VSP) < http://dqo.pnl.gov/vsp> and/or MARSSIM sampling plans generated on a triangular pattern. In these cases, locations would be referenced from structural interfaces located with a laser measuring device or equivalent.

2. Grid blocks are marked on the floor and lower wall (up to 2 m) using a chalk line or other appropriate marking system. The starting point for referencing the grid is usually selected as the southwest corner of the room. Grid blocks can be identified by the southwest coordinate for floors and the lower left coordinate for walls, or by an assigned grid block number (Figures 6.2-4 and 6.2-5).

3. Grid points (grid line intersections) are marked using paint, tape, grease pencil, chalk or equivalent. The licensee or contractor's permission is required before using paint or other markers which may deface the surface.

4. Grid points are identified using an alpha-numeric system. Lines perpendicular to the baseline are identified alphabetically; lines parallel to the baseline are identified by a number indicating the distance from the baseline.

5. Where buildings contain multiple rooms, it may be convenient to individually grid each room, rather than attempting to include all areas on the same system. This is at the discretion of the Site Coordinator. Grid establishment in small rooms (less than 10 m^2) and in unaffected (Class 3) areas is at the discretion of the Site Coordinator.

6. Upper walls and ceiling areas are not usually gridded. Measurements on these surfaces are referenced to prominent building features or to locations corresponding to the gridded floor and lower walls.

Open Land Areas

The equipment that should be used is listed below:

- ✓ Measuring tape.
- ✓ Grid markers; stakes, flags, flagging tape.
- ✓ Chaining pins.
- ✓ Waterproof marker.
- ✓ Fluorescent paint.
- ✓ Mallet.
- ✓ GPS system (optional, if available).

The preferred ORISE interval for Cartesian grid systems is 10 m. However, this interval may be decreased or increased, depending on the total property area and the radiological history of the site.

The approach for utilizing the Cartesian grid system is as follows:
Grid line intersections, also called grid points are marked using stakes, hubs, spikes, paint, flags, or survey tape. The selection of an appropriate marker depends upon the characteristics and routine uses of the surface.
A specific grid point is identified as the reference for the grid. This point, generally near the center or at a corner of the property, is identified on the grid marker as point 0,0.

Coordinates of other grid points are referenced to the 0,0 point using alphanumeric identifiers. The numeric identifier indicates the distance (meters or feet) and the alphabetic identifier indicates the direction from the reference point, i.e. N (north), S (south), E (east), W (west), or L (left of baseline) and R (right of baseline). Coordinates are identified on or adjacent to the grid point markers. Any location within a grid system may be designated by measuring the distance and direction from the point of interest to a grid point marker. Some examples of figures based on Cartesian grid systems are shown on Figures 6.2-1, 6.2-2 and 6.2-3.

With the recent improvements of GPS/GIS technology, more emphasis should be placed on utilizing geographic coordinate systems for indicating locations in large land areas. Procedures for setting up equipment are addressed in Sections 5.13, 7.7, and 7.8. However, specific approaches will by determined by project-specific Data Quality Objectives.

Both Cartesian gridding and geographic coordinate systems methods are mentioned to allow flexibility in the survey design process.

Site Drawings

Site drawings may be generated by a number of different methods – hand-drawn, photographs, printouts from drawing applications, georeferenced aerial maps, GPS/GIS systems, etc.

Information that may be included on these graphical representations, but are not limited to:

- site or area boundaries
- grid layout, including coordinate references
- metadata, such as task number, site name, surveyor(s), date, etc.
- referential indicators, such as scale, compass direction, labels, etc.
- surveyed areas and instrumentation used
- sample locations
- inaccessible areas, such as excavations, materials storage, etc.

Section 6.3 – Job Hazard Analysis – Site Clearing and Gridding

Discussion

To provide a method for identifying areas of elevated surface radiation.

Clearing to Provide Access

JOB HAZARD ANALYSIS		
ACTIVITY	**HAZARD**	**CONTROL**
A. Brush clearing (General)	A1. Tripping	A1. Ensure field of view is unobstructed
	A2. Eye Injury	A2. Wear eye protection
	A3. Biological (Snakes, Ticks)	A3. Wear light colored clothing. Use insect repellant, or snake guards.
B. Machetes	B1. Cuts (minor to severe)	B1. Use proper techniques, wear leg guards
	B2. Loss of grip	B2. Use proper techniques, wear leather gloves
C. Chain saws, brush trimmers, mowers	C1. Fire (fuel)	C1. Fire extinguishers, use proper fueling techniques
	C2. Back injury	C2. Use proper lifting, starting techniques
	C3. Cuts (severe)	C3. Wear leather gloves, steel-toed shoes, leg guards, ensure chain brake and chain saw is functioning properly
	C4. Hearing	C4. Wear hearing protection

Establishing a Reference Grid

JOB HAZARD ANALYSIS		
ACTIVITY	**HAZARD**	**CONTROL**
A. Measuring Area	A1. Tripping	A1. Examine area prior to beginning work, mark or otherwise note obstructions
	A2. Vehicular Traffic	A2. Wear orange vests, adhere to site traffic safety pattern requirements
	A3. Overhead Obstruction	A3. See A1, wear hard hat
B. Marker Placement	B1. Pinch points when driving stakes	B1. Use proper techniques, wear leather gloves

Section 7.0

Scanning & Measurement Techniques

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Section 7.1 – Surface Scanning

Purpose

To provide a method for identifying areas of elevated surface radiation.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

Procedure

Surfaces are scanned to determine the level of gross activity present. Action levels are determined based on guidelines established for each site (see Sections 7.3 – 7.5) and serve as indicators that further investigation is necessary. Scans are conducted for all radionuclides potentially present based on the site history. Monitoring for the unexpected is also recommended. Headphones are recommended for all scanning activities.

Gamma Scanning

List of Equipment

- ✓ Sodium iodide gamma scintillator: Model 489-55, Victoreen Instrument Co.; Model SPA-3, Eberline Instrument Corporation; or equivalent (Thin crystal, Model PG-2, Eberline Instrument Corporation, Model G5 "FIDLER", Bicron Corporation, or equivalent may be used when low energy photons are the radiation of concern).
- ✓ Portable ratemeter or ratemeter-scaler: Model PRM-6; Eberline Instrument Corporation; Model 2221, Ludlum Instrument Corporation; or equivalent, equipped with audible speaker.
- ✓ Cable: As appropriate (see Section 5).
- ✓ Check source.
- ✓ Record forms.
- ✓ GPS equipment, optional (Refer to Section 7.7 for use)

Gamma Operation Check-out

Assemble equipment, check battery, and adjust high voltage, if necessary. Check background and gamma check source count rates. Follow procedures described in Section 5.

Gamma Scanning

1) Set the instrument for "FAST" response.
2) Pass the detector slowly over the surface. The detector is maintained at a distance as close to the surface as conditions allow, nominally one to four centimeters. The speed of detector movement will vary depending upon the radionuclide of concern, the experience of the surveyor, and the required observation interval, but is typically 0.5 to 1.0 m per second. Gamma scanning is usually performed by swinging the detector in front of the body in a pendulum manner while progressing at the speed of a slow walk.
3) Note increases in count rate as indicated by the audible output. Compare count rates to the established site action level as discussed below.

   If the scan sensitivity, which is based on available data and the Site Coordinator's professional experience, is greater than the guideline, then any locations of direct radiation distinguishable from background will require the surveyor to pause, investigate the area, and mark positive findings.

   If the scan sensitivity is less than the guideline, establish action levels as either a multiplier of the ambient background or a specific count rate.

   NUREG 1507[1] provides acceptable gamma scanning minimum detectable concentrations for the more commonly encountered gamma-emitting radionuclides.
4) Mark areas that meet or exceed action levels using survey flags for open land areas and paint, grease pencil or other appropriate method for other surfaces. Further investigation is necessary at these locations.
5) Scan coverage will be determined by the survey unit classification or other parameters such as the site's radiological history, contamination potential, and findings as the survey progresses. For example, Class 1 areas will require high density scans (1 meter intervals), Class 2 areas will require moderate density scans (3-5 meter intervals), Class 3 areas will require low density scans (5-10 meter intervals).
6) After a specific area (usually a grid block or survey unit), has been scanned, map the dimensions of any areas of concern; record locations and levels of ambient gamma radiation and elevated gamma radiation on the appropriate survey form (Figures B-9, B-10, or equivalent).

Beta-Gamma Scanning

List of Equipment

- ✓ Beta detector: Model 489 (GM "Pancake"), Victoreen Instrument Co.; Model HP-260 (GM "Pancake"), Model 43-68 (proportional), Ludlum Instrument Corporation; or equivalent.
- ✓ Portable ratemeter-scaler: Model PRM-6 or PRS-1, Eberline Instrument Corporation; Model 2221, Ludlum Instrument Corporation; or equivalent, equipped with audible speaker.
- ✓ Cable: As appropriate (see Section 5)
- ✓ Check source
- ✓ Record forms

Beta-Gamma Operational Check-Out

Assemble equipment, check battery, and adjust high voltage and threshold, if necessary. Check background and check source count rates. Follow procedures described in Section 5.

Beta-Gamma Scanning

1) Pass the detector slowly over the surface. The detector is maintained at a distance as close to the surface as conditions allow, nominally no more than one centimeter. The speed of detector movement will vary depending upon the radionuclide of concern, the experience of the surveyor, and the required observation interval, but is typically one-half to one detector width per second.

2) Note increases in count rate as indicated by the audible output. Compare count rates to the established site action level as discussed below.

   If the scan sensitivity, which is based on available data and the Site Coordinator's professional experience, is greater than the guideline, then any locations of direct radiation distinguishable from background will require the surveyor to pause, investigate the area, and mark positive findings.

   If the scan sensitivity is less than the guideline, establish action levels as either a multiplier of the ambient background or a specific count rate. See Section 7.4 for determination of action levels.

ORISE protocols and NUREGs 1507 and 1575[2] provide additional information for calculating specific scan MDCs.

3) Mark areas that meet or exceed action levels using flags, stakes, paint, chalk, markers, etc., as necessary. Further investigation is necessary at these locations.

4) Continue traversing the area at close intervals. Due to the short range of the beta radiation and the directional dependence of the detector, scanning intervals may overlap.

5) After a specific area (usually a grid block or survey unit) has been scanned, map the dimensions of any areas of concern. Record all scan data, including the locations and activity levels of elevated radiation on the appropriate survey forms (Figures B-9, B-10, or equivalent).

Alpha Scanning (with hand-held meters)

List of Equipment

- ✓ Alpha detector: Model AC3-7 (ZnS), AC3-8, or HP-100A, Eberline Instrument Corporation; Model 43-68 (proportional), Ludlum Instrument Corporation, or equivalent.
- ✓ Portable ratemeter-scaler: Model PRS-1; Eberline Instrument Corporation; Model 2221 or 2223, Ludlum Instrument Corporation; or equivalent, equipped with audible speaker.
- ✓ Cable: As appropriate (see Section 5).
- ✓ P-10 gas (for proportional detectors).
- ✓ Check source.
- ✓ Record forms.

Alpha Operational Check-Out

Assemble equipment, check battery, and adjust high voltage and threshold, if necessary. Purge detector (proportional only) with P-10 gas. Check background and alpha check source count rates. Follow procedures described in Section 5.

Alpha Scanning

1) Pass the detector slowly over the surface. The detector is maintained at a distance as close to the surface as conditions allow, nominally less than one centimeter. The speed of detector movement will vary depending upon the experience of the surveyor and the action level/guideline but is typically 2 to 5 centimeters per second.

2) The alpha background count rates for most detectors are very close to zero. This, combined with typically low activity guidelines for alpha-emitters requires that the surveyor pause liberally when counts are detected, investigate the area, and mark positive findings. Compare count rates to the established site action level. See Section 7.3 for determination of action levels.

   ORISE protocols and NUREG-1575 provide additional information on calculating alpha scan MDCs.

3) Mark areas that meet or exceed site action levels using paint, chalk, or grease pencil. Further investigation is necessary at these locations.

4) Continue traversing the area at close intervals. Due to the short range of the alpha radiation and the directional dependence of the detector scanning, intervals may overlap.

5) After a specific area (usually a grid block or survey unit) has been scanned, map the dimensions of any areas of concern. Record scan data, including the operational mode (i.e., alpha only), if applicable, and the locations and activity levels of elevated radiation on the appropriate survey forms (Figures B-9, B-10, or equivalent).

Alpha+Beta Scanning (with hand-held meters)

List of Equipment

- ✓ Alpha-beta detector: Model 43-68 (proportional) or 43-89, Ludlum Instrument Corporation, or equivalent.

  NOTE: These detectors may be used to scan for either alpha or alpha-beta activity by varying the high voltage on the ratemeter-scaler or simultaneous alpha and beta counting using the 43-89 coupled to the 2223.

- ✓ Portable ratemeter-scaler: Model PRS-1; Eberline Instrument Corporation; Model 2221 or 2223, Ludlum Instrument Corporation; or equivalent, equipped with audible speaker.

- ✓ Cable: As appropriate (see Section 5).

- ✓ P-10 gas.
- ✓ Check source.
- ✓ Record forms.

Alpha+Beta Operational Check-Out

Assemble equipment, check battery, and adjust high voltage and threshold, if necessary. Purge detector with P-10 gas. Check background and alpha check source count rates. Follow procedures described in Section 5.

Alpha+Beta Scanning

1) Pass the detector slowly over the surface. The detector is maintained at a distance as close to the surface as conditions allow, nominally no more than one centimeter. The speed of detector movement will vary depending upon the radionuclide of concern and the experience of the surveyor, but is typically one detector width per second. The detector should be kept as close to the surface as conditions allow.

2) Note increases in count rate as indicated by the audible output. Compare count rates to the established site action level. If the scan sensitivity, which is based on available data and the Site Coordinator's professional experience, is greater than the guideline, then any locations of direct radiation distinguishable from background will require the surveyor to pause, investigate the area, and mark positive findings.

   If the scan sensitivity is less than the guideline, establish action levels as either a multiplier of the ambient background or a specific count rate. See Section 7.3 and 7.4 for determination of action levels. ORISE protocols and NUREGs 1507 and 1575 provide additional information on calculating alpha scan MDCs.

3) Mark areas that meet or exceed site action levels using paint, chalk, or grease pencil. Further investigation is necessary at these locations.

4) Continue traversing the area at close intervals. Due to the relatively short range of the alpha and beta radiation and the directional dependence of the detector, scanning intervals may overlap.

5) After a specific area (usually a grid block or survey unit) has been scanned, map the dimensions of any areas of concern. Record scan data, including the operational mode (i.e., alpha+beta) and the locations and activity levels of elevated radiation on the appropriate survey forms (Figures B-9, B-10, or equivalent). **NOTE:** It may be necessary to perform a scan for alpha only in conjunction with the alpha plus beta scan since significant levels of alpha activity may be masked by the background levels obtained when operating in the alpha plus beta plateau region.

Floor Monitor Scanning (for alpha and/or alpha plus beta)

List of Equipment

- ✓ Proportional floor monitor: Model 239-1 (?43-37), Ludlum Instrument Corporation, or equivalent.
- ✓ Portable ratemeter-scaler: Model 2220 or 2221, Ludlum Instrument Corporation; or equivalent, equipped with audible speaker.
- ✓ Cable: As appropriate (see Section 5).
- ✓ P-10 gas.
- ✓ Check source.
- ✓ Record forms.

Floor Monitor Operational Check-Out

Assemble equipment, check battery, and adjust high voltage and threshold, if necessary. Check background and check source count rates for the appropriate detection mode (alpha or alpha plus beta). Follow procedures described in Section 5.

Floor Monitor Scanning

1) Pass the detector slowly over the floor. The detector is maintained at a distance as close to the surface as conditions allow, nominally one centimeter. The speed of detector movement will vary depending upon the radionuclide of concern and the experience of the surveyor, but is typically one detector width per second. The detector should be kept as close to the surface as conditions allow.
2) Note increases in count rate as indicated by the audible output.

   If the scan sensitivity, which is based on available data and the Site Coordinator's professional experience, is greater than the guideline, then any locations of direct radiation distinguishable from background will require the surveyor to pause, investigate the area, and mark positive findings.

   If the scan sensitivity is less than the guideline, establish action levels as either a multiplier of the ambient background or a specific count rate.

   NOTE: Because the floor monitor is not calibrated, it serves as a qualitative scanning method. Specific count rate action levels are therefore not determined. General MDCs are available in ORISE protocols.

3) Circle of increased count rate using paint, chalk, or grease pencil. Further investigation is necessary at these locations.

4) Continue traversing the area at close intervals. Due to the relatively short range of the alpha and beta radiation and the directional dependence of the detector, scanning intervals may overlap.

5) After a specific area (usually a grid block or survey unit) has been scanned, map the dimensions of any areas of concern. Record scan data, including the operational mode (i.e., alpha or alpha+beta) and the locations and activity levels of elevated radiation on the appropriate survey forms (Figures B-9, B-10, or equivalent).

   NOTE: It may be necessary to perform a scan for alpha only in conjunction with the alpha plus beta scan since significant levels of alpha activity may be masked by the background levels obtained when operating in the alpha plus beta plateau region. Voltage adjustments should be made accordingly.

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[1] U.S. Nuclear Regulatory Commission. NUREG-1507, Minimum detectable concentrations with typical radiation survey instruments for various contaminants and field conditions. Washington, DC; June 1998.

[2] U.S. Nuclear Regulatory Commission. NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual. Washington, DC; Revision 1, August 2000.

Section 7.2 – Gamma Logging of Boreholes

Purpose

To describe the method for performing subsurface gamma logging measurements in boreholes.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Scintillation detector: Model 489-55 NaI detector, Victoreen Instrument Company; or equivalent.
- ✓ Portable ratemeter-scaler: Model 2200, Ludlum Instrument Corporation; or equivalent.
- ✓ Cable; as appropriate (see Section 5.3).
- ✓ Lead collimator for scintillation detector, approximately 1 cm thick with four 2.5 cm x 7 mm slots at the detector midpoint, (ORISE design).
- ✓ Winch assembly for lowering and raising collimated detector in borehole, (ORISE design).
- ✓ As required, capped plastic (PVC) pipe of sufficient length to case borehole to desire logging depth. Pipe diameter will be determined by the dimensions of the drill bit.
- ✓ Plastic bags (large enough to cover lead collimator).
- ✓ Check source.
- ✓ Record forms.

Gamma Logging Procedure

1) Assemble equipment; turn on scaler, test battery, and adjust voltage, if necessary. Check background count rate and the detector response to the gamma check source. Follow procedures described in Section 5.3.

2) Enclose the collimated detector assembly in double plastic bags to protect detector against direct contact with water or soil from the borehole. If the borehole has a tendency to cave in or contains water, insert an appropriate length of plastic pipe.

3) Position the winch assembly over the borehole.

4) Lower the detector assembly until the collimator slots are level with the ground surface.

5) Reset the depth recorder to 0.

6) Lower the detector assembly slowly into the borehole, noting the count ratemeter response for indications of locations of elevated gamma activity. Record the depths of these locations.

7) When the detector reaches the bottom of the borehole or borehole liner pipe, record the depth of the hole.

8) Set the scaler timer to 0.5 or 1 minute, depending upon contaminant and ambient detection level; start and accumulate the counts.

9) Record depth and count rate on the Borehole Logging Form (Figure B-11, or equivalent).

10) Raise the detector to the nearest even multiple of 30 cm (1 unit on the depth recorder) and repeat steps 8 and 9.

11) Repeat at 30 cm intervals and at noted locations of elevated activity until a depth of 15 cm is reached.

12) Obtain a measurement at 15 cm below the ground surface and at the ground surface.

13) If the identities and ratios of the radionuclides in the subsurface soil are known, calibration factors can be developed and applied to the individual count rates at various depths to estimate the concentrations in picocuries per gram. If the ratios of radionuclides in the subsurface soil have been shown to vary, the logging is used only to indicate locations and relative levels of soil concentrations.

    NOTE: Borehole logging can also be done using a non-collimated NaI for shallow or small diameter boreholes or for collecting general information concerning the radiation activity characteristics of the borehole.

Section 7.3 – Alpha Radiation Measurement

Purpose

To describe the method for measuring total alpha radiation levels on equipment and building surfaces

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Portable ratemeter-scaler: Model 2200, Ludlum Instrument Corporation; or equivalent.
- ✓ Alpha detector: Model AC3-7, Eberline Instrument Corporation; Model 43-68 or 43-89, Ludlum Instrument Corporation; or equivalent.
- ✓ Cable; as appropriate (see Section 5.4 or 5.6).
- ✓ Check source.
- ✓ Record forms.

Operational Check-Out

1) Assemble detector unit. If using proportional equipment, purge detectors before beginning operational check. Check battery, and adjust high voltage and threshold. Follow procedures described in Section 5.4 or Section 5.6.
2) Check the background count rate and the response of the detector to the alpha check source as described in Section 5 (if the check source response is outside the established limits the unit is to be removed from service until the problem can be identified and corrected). Record values on the Instrument Operational Check-out Form (Figure B-1 or equivalent).

NOTE: If the site background is not consistent with the predetermined response range, a new response range shall be established at the specific site and noted on the Instrument Operational Check-out Form. The daily background count should be consistently measured on a surface in an area deemed appropriate by the Site Coordinator.

3) When applicable, calculate the "field action levels" for the instrument combination based on the specific site criteria and background.

$$Action\ level\ (counts) = [site\ criteria(dpm/100\ cm^2) \times \varepsilon_{tot} \times G \times T] + B \times T$$

where:

B = construction material-specific background (cpm)

T = count time (minutes)

$$G = \text{geometry} = \frac{Physical\ \ Detector\ \ Area\ cm^2}{100}$$

43-68 physical detector area = 126 cm^2

43-89 physical detector area = 117 cm^2

AC3-7 physical detector area = 74 cm^2

$$\varepsilon_{Tot} = \text{total efficiency} = \frac{counts}{disintegration} = \varepsilon_i \times \varepsilon_s$$

ε_i = instrument efficiency

ε_s = source efficiency (0.25 for alpha)

A field count at or above the calculated value indicates that further investigation of the area is necessary.

NOTE: For a particular site, the action level may be established as any activity exceeding background.

Measurements

1) Select an appropriate counting time. A counting time is selected that will achieve a minimum detectable concentration value less than 50% of the applicable criteria. For most radionuclides a 1 minute count is appropriate.

2) When using 2223/43-89 combination, instrument must be switched to alpha mode.

3) Place the detector face in contact with the surface to be surveyed. The detector face is constructed of a very thin and fragile mylar material, so

care must be exercised to avoid damage by rough surfaces or sharp objects.

4) Set the meter timer switch, press the count reset button, and accumulate the count events until the meter display indicates that the count cycle is complete.

5) Record the gross count and time on the appropriate Survey Form (Figures B-9, B-12, or equivalent). Record the location, surface type and condition on Survey Form.

6) Calculate alpha dpm/100 cm^2 by subtracting an appropriate material-specific background to obtain net counts and applying appropriate time, efficiency, and physical detector area factors.

$$\alpha\ dpm/100\ cm^2 = \frac{N}{T \times \varepsilon_{tot} \times G \times other\ Modifying\ Factors}$$

where:

N = net counts (counts)

T = count time (min)

$$G = \text{geometry} = \frac{Physical\ Detector\ Area\ cm^2}{100}$$

43-68 physical detector area = 126 cm^2

43-89 physical detector area = 117 cm^2

AC3-7 physical detector area = 74 cm^2

$$\varepsilon_{Tot} = \text{total efficiency} = \frac{counts}{disintegration} = \varepsilon_i \times \varepsilon_s$$

ε_i = instrument efficiency

ε_s = source efficiency (0.25 for alpha)

Other modifying factors include corrections for the attenuation effects of overlying materials, surface types, etc. These factors may be incorporated into a revised ε_s.

NOTE: If a complete area scan has not been done, the area around the measurement locations should be scanned to determine the homogeneity of the measured activity level in the area. Dimensions and activity levels of inhomogeneities should be documented on the Surface Activity Survey Form (Figure B-9 or equivalent).

Section 7.4 – Beta Radiation Measurement

Purpose

To describe the method for measuring total beta radiation levels on equipment and building surfaces.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

✓ Portable ratemeter-scaler: Model PRS 1 (Rascal), Eberline Instrument Corporation; Model 2221 or 2223; Ludlum Instrument Corporation; or equivalent.

✓ Beta detector: Model HP 260 (GM "Pancake"), Model 43 68 (proportional) or Model 43-89, Ludlum Instrument Corporation; or equivalent.

✓ Cable: as appropriate (see Section 5).

✓ Alpha shield - The detector face may be covered with a thin layer of tracing paper to provide a total thickness of 7 mg/cm^2 and to increase the degree of protection of the detector face from accidental puncture and contamination, or to intentionally block alpha radiation. A 43-68 detector may be fitted with a 3.8 mg/cm^2 thickness mylar window. The detector must be calibrated in the configuration that it will be used in the field.

✓ Check source.

✓ Record forms.

Operational Check-Out

1) Assemble detector unit. Purge detector model 43-68 before beginning operational check. Check battery and adjust high voltage and threshold. Follow procedures described in Section 5.

2) Check the background count rate and the detector response to the check source (if the check source response is outside the established limits, the unit is to be removed from service until the problem can be identified and corrected). Record the values on the daily Instrument Operational Check-Out Form (see Section 5).

   NOTE: If the site background is not consistent with the predetermined response range, a new response range shall be established at the specific site and noted on the Instrument Operational Check-out Form, Figure B-1. The daily background count should be consistently measured on a surface in an area deemed appropriate by the Site Coordinator.

3) When applicable, calculate the "field action levels" for the instrument combination based on the specific site criteria and background.

   Action Level (counts) = [site criteria (dpm/100 cm^2) x ε_{tot} x G x T] + B x T

   where:
   B = background (cpm)

   $$G = \text{geometry} = \frac{Physical\ Detector\ Area\ cm^2}{100}$$

   HP-260 physical detector area = **20 cm^2**
   43-68 physical detector area = **126 cm^2**
   43-89 physical detector area = **117 cm^2**

   T = count time (min)

   $$\varepsilon_{Tot} = \text{total efficiency} = \frac{counts}{disintegration} = \varepsilon_i \times \varepsilon_s$$

   ε_i = instrument efficiency

   ε_s = source efficiency (unless otherwise determined: 0.25 for β_{max} < 400 keV or 0.5 for β_{max} > 400 keV)

   A field count at or above the calculated value indicates that further investigation of the area is necessary.

   NOTE: For a particular site, the action level may be established as any activity exceeding background.

Measurements

1) Select an appropriate counting time. A counting time is desired which will achieve a minimum detectable concentration value less than 50% of the applicable criteria. For most radionuclides, a one minute count is appropriate.

   NOTE: If the count must be corrected for alpha contribution, cover the detector face with an alpha shield. If correction for varying ambient gamma backgrounds is required, refer to the following section within this procedure regarding "Shielded/Unshielded Measurements". Place the detector on one of the alpha calibration sources having a 2π surface emission rate greater than 25,000 cpm.

2) Instrument must be switched to beta mode when using 2223/43-89 combination.

3) Place the detector in contact with the surface being surveyed. Avoid placing the detector on surfaces with sharp projections which may puncture the thin detector face.

4) Set the meter timer switch, press the count reset button, and accumulate the count events until the meter display indicates that the count cycle is complete.

5) Record the gross count and time on the appropriate survey form (Figures B-9, B-12, B-13, B-14 or equivalent). Record the location, surface type and condition on Survey Form.

6) Calculate beta dpm/100 cm^2 by subtracting an appropriate material-specific background to obtain net counts and applying appropriate time, efficiency, and physical detector area factors.

$$\beta\ dpm/100\ cm^2 = \frac{N}{T \times \varepsilon_{tot} \times G \times other\ Modifying\ Factors}$$

where:

N = net counts (counts)

T = count time (min)

$$G = \text{geometry} = \frac{Physical\ Detector\ Area\ cm^2}{100}$$

HP-260 physical detector area = 20 cm^2

43-68 physical detector area = 126 cm^2

43-89 physical detector area = 117 cm^2

$$\varepsilon_{Tot} = \text{total efficiency} = \frac{counts}{disintegration} = \varepsilon_i \times \varepsilon_s$$

ε_i = instrument efficiency

ε_s = source efficiency (unless otherwise determined: unless otherwise determined: 0.25 for $\beta_{max} < 400$ keV or 0.5 for $\beta_{max} > 400$ keV)

Other modifying factors include corrections for the attenuation effects of overlying materials, surface types, etc. These factors may be incorporated into a revised ε_s.

NOTE: If a complete area scan has not been done, the area around the measurement location should be scanned to determine the homogeneity of the measured activity level in the area. Dimensions and activity levels of inhomogeneities should be documented on the appropriate survey forms (Figure B-9 or equivalent).

Shielded/Unshielded Measurements

NOTE: This procedure is followed when survey unit ambient background gamma radiation levels vary significantly from those in the reference area(s).

1) Perform steps step 1-5 in the Measurements section above **both with and without** a minimum 3/8"-thick plexiglass shield on the detector face.

2) Record both shielded and unshielded gross counts, count time, location, surface type, and surface condition on the appropriate survey form (Figures B-9, B-12, B-13, B-14 or equivalent).

3) Perform step 6 in the Measurements section above after first calculating the value for N–using the appropriate reference material-specific R_{rm}, determined per Section 5.5, 5.6, or 5.7–as follows:

$$N = \left(R_{u,su} - R_{s,su}\right) - R_{rm}$$

where:
N = net counts

$R_{u,su}$ = unshielded survey unit count rate

$Rs_{,su}$ = shielded survey unit count rate

R_{rm} = reference material count rate

Section 7.5 – Gamma Radiation (Exposure Rate) Measurement

Purpose

To describe the method for measuring external gamma radiation levels in buildings and over ground surfaces.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure.

Pressurized Ion Chamber (PIC) (0 - 500 µR)

List of Equipment

- ✓ Pressurized Ion Chamber: Model RSS 112, Reuter Stokes Co.
- ✓ Tripod.
- ✓ Check source.
- ✓ Record forms.

Operational Check-Out

Assemble instrument, turn on, check batteries, and allow the instrument to stabilize approximately 5 minutes. Check background level and response to the gamma check source. Follow procedures described in Section 5.

Measurements

1) Adjust the tripod to place the center of the detector chamber approximately 1 m above the surface.

2) With unit in the CURRENT DATA/DOSE INTEGRATOR mode and the power switch in the read position (see Section 5.8), press the reset integrator key in order to re-zero the dose integrator display (located in

the lower right of the data screen). Allow the unit to acquire a new average exposure rate over a 1 to 2 minute period. Record this value on the appropriate form (Figure B-3, B 15, or the equivalent).

3) An action level will be determined based on the exposure rate guidelines that have been established for the site. For a particular site the action level may be established as any activity exceeding background. A field measurement at or above this value indicates that further investigation at this location is necessary.

Bicron Microrem Meter (0 to 200 mrem/h)

List of Equipment

- ✓ Bicron Micro-rem meter.
- ✓ Check source.
- ✓ Record forms.

Operational Check-Out

1) Turn unit on. Check battery and high voltage.

2) Check the background dose rate and the detector response to the gamma check source dose rate. If the check source response is outside the established limits, the unit is to be removed from service until the problem can be identified and corrected. Record the values on the daily instrument PIC Field Check-out Form. (See Section 5).

   NOTE: If the site background is not consistent with the predetermined response range, then a new response range shall be established at the specific site and noted on the Instrument Operational Check-Out Form.

Measurements

1) Hold the meter at 1 meter above the surface.

   NOTE: Ensure that the check source has been removed from inside the detector prior to making measurements.

2) Obtain 10 instantaneous readings and record on the appropriate form (Figure B-3, B-15, B-22, or equivalent). Average these values to determine the dose rate at this location.

   NOTE: Although the meter displays the data in µrem/h, the µrem/h to µR/h conversion is essentially unity.

3) An action level will be determined based on the exposure rate guidelines that have been established for the site. For a particular site the action level may be established as any activity exceeding background. A field measurement at or above this value indicates that further investigation at this location is necessary.

Sodium Iodide Scintillator (0 to 500 Kcpm: approximate exposure rate range (0-1000 µR/h))

List of Equipment

- ✓ Portable ratemeter: Model PRM 6, Eberline Instrument Corporation; or equivalent.
- ✓ Sodium iodide detector: Model 489 55, Victoreen Instrument Co; Model SPA 3, Eberline Instrument Corporation; or equivalent.
- ✓ Cable: As appropriate (see Section 5).
- ✓ Check source.
- ✓ Record forms.

Operational Check-Out

1) Assemble unit, check battery, and adjust high voltage, as necessary. Set the PRM 6 for 'SLOW' response.

2) Check the background count rate and the detector response to the gamma check source. If the check source response is outside the established limits, the unit is to be removed from service until the problem can be identified and corrected. Record the values on the daily Instrument Field Check Form (see Section 5).

   NOTE: If the site background is not consistent with the predetermined response range, then a new response range shall be established at the specific site and noted on the Instrument Operational Check-Out Form.

Measurements

1) Place the detector at the position where the measurement is desired.

2) Observe the count rate displayed on the meter; switch the range selector until the meter response is over 10 percent of full scale.

3) Estimate the average count rate and record it on the appropriate record form (Figures B-9, B-10, B-13, B-15, or equivalent).

4) Convert the count rate (cpm) to exposure rate (μR/h) using factors determined by cross calibration with the Pressurized Ionization Chamber (see Section 5.0).

5) An action level will be determined based on the exposure rate guidelines that have been established for the site. For a particular site the action level may be established as any activity exceeding background. A field measurement at or above this value indicates that further investigation at this location is necessary.

Compensated GM Detector (0 to 999,999) cpm: approximate exposure rate range (500 μR/h to 50 mR/h))

List of Equipment

- ✓ Portable Scaler: Model PRS 1 (Rascal), Eberline Instrument Corporation; Model 2221, Ludlum Instrument Corporation; or equivalent.
- ✓ Compensated GM detector: Model HP 270, Eberline Instrument Corporation; or equivalent.
- ✓ Cable: As appropriate (see Section 5).
- ✓ Check source.
- ✓ Record forms.

Operational Check-Out

1) Assemble detector unit (detector shield closed), check battery, and adjust high voltage and threshold, if necessary.

2) Check the background count rate and the detector response to the gamma check source. If the check source response is outside the established limits, the unit is to be removed from service until the problem can be identified and corrected. Record the values on the daily Instrument Operational Check-Out Form (see Section 5).

   NOTE: If the site background is not consistent with the predetermined response range, then a new response range shall be established at the specific site and noted on the Instrument Operational Check-Out Form.

Measurements

1) Place the GM detector at the position where the measurement is desired.

2) Set the meter timer switch to 1 minute, press the count reset button, and accumulate count events until the meter display indicates the count cycle is complete.

3) Record the count rate measurement on the appropriate record form (Figures B-9, B-10, B-13, B-14, B-15, or equivalent).

4) Calculate the exposure rate by applying the calibration factor determined by comparison with the Pressurized Ionization Chamber or by exposure to a source of known radiation intensity (Section 5.8).

Ionization Survey Meter (0 to 20 R/h)

List of Equipment

- ✓ Ionization Survey Meter: Model 36100, Keithly Instruments, Inc.; or equivalent.
- ✓ Record forms.

Operational Check-Out

Check battery and adjust zero balance control. If malfunctions are noted, remove instrument from service until problems are identified and corrected.

Measurements

1) Place the detector at the position where the measurement is desired.

2) Observe the rate displayed on the meter; switch the range selector until the meter response is over 10 percent of full scale. Record measurements on appropriate record form (Figures B-9, B-10, B-13, B-14, B-15, or equivalent).

Section 7.6 – Beta Measurements using the GM-Based Pipe Monitor

Purpose

To describe the method for measuring total beta radiation levels in embedded piping surfaces using the pipe monitor.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Portable ratemeter-scaler: Three Model 2221s or 2223s; Ludlum Instrument Corporation; or equivalent.
- ✓ Pipe Monitor: ORISE-designed with three GM "Pancake" detector tubes.
- ✓ Cable: Three 50-foot C-BNC; or other connectors, as applicable.
- ✓ Rope (50 to 100 feet) and/or plumber's snake.
- ✓ Check source.
- ✓ Record forms.

Operational Check-Out

1) Assemble detector array and couple each detector to the appropriate ratemeter-scaler. Check battery strength and adjust the high voltage and threshold, if necessary, for each instrument. Follow procedures described in Section 5 of the Survey Procedures Manual.

2) Check the background count rates and the check source response for each detector (if the check source response is outside the established limits, the unit is to be removed from service until the problem can be identified and corrected). Record the values on the Daily Instrument Operational Check-Out Form (see Section 5 of the Survey Procedures Manual).

   NOTE: If the site background is not consistent with the predetermined response range, a new response range shall be established at the specific site and noted on the Instrument Operational Check-Out Form, (Figure B-26 or equivalent). The daily background count should be consistently measured on a surface in an area deemed appropriate by the Site Coordinator.

3) When applicable, calculate the "field action levels" for the instrument combination based on the specific site criteria and background.

$$Action\ Level\ (counts) = [site\ criteria\ (dpm/100\ cm^2) \times \varepsilon_{tot} \times G \times T] + B \times T$$

where:

B = background (cpm);

G = Geometry = $\frac{Physical\ Detector\ Area\ (cm^2)}{100}$

Physical Detector Area (for individual detectors)= 20 cm^2
Physical Detector Area (for pipe monitor array) = 168 cm^2
(unless otherwise specified by the Site Coordinator for larger diameter pipes (>4"))

T = count time (min)

ε_{Tot} = total efficiency = $\frac{counts}{disintegration}$ = ε_i x ε_s

ε_i = instrument efficiency

ε_s = source efficiency (unless otherwise determined: 0.25 for β_{max} < 400 keV or 0.5 for β_{max} > 400 keV)

A field count at or above the calculated value indicates that further investigation of the area is necessary. (**NOTE**: For a particular site, the action level may be established as any activity exceeding background).

Scanning and Measurements

1) Feed the plumber's snake with attached rope through the down-stream pipe access opening to the up-stream access opening survey start point. Attach the rope clip to the pipe monitor front eye-bolt. Pull the pipe monitor through the piping from the down-stream access point using the rope. As the monitor goes through the pipe, pause the monitor for 5 to 10 seconds at pipe-length intervals specified I the survey plan. A 100% scan will require pausing the detector at intervals equal to the array length of approximately every 10 cm. Observe both the audio and digital display outputs of each ratemeter-scaler for indications of elevated count rates.

2) At judgmental, random, or systematic locations, perform a measurement of surface activity. A counting time is desired which will achieve a minimum detectable concentration value less than 50% of the applicable criteria. For most radionuclides, a 1-minute count is appropriate.

   NOTE: If the count must be corrected for alpha contribution, cover the detector faces with an alpha shield.

3) With the pipe monitor positioned at the measurement location, set each ratemeter-scaler time switch, press the count reset buttons, and accumulate the count events until the meter displays indicate that the count cycles are complete.

4) Record the gross counts and times for each detector on the appropriate survey form (Figures B-9, B-12, B-13, B-14, or equivalent). Record the location (distance traveled into the pipe and the type and location of the pipe), surface type, and condition on the Survey Form.

5) Calculate beta dpm/100 cm^2 for each individual detector by subtracting an appropriate material-specific background to obtain net counts and applying appropriate time, efficiency, and physical detector area factors. (See step 6 for variable substitutions to calculate <u>total area</u> activity).

$$\beta\ dpm/100\ cm^2 = \frac{N}{T \times \varepsilon_{tot} \times G \times other\ Modifying\ Factors}$$

where:
N = net counts (counts)

T = count time (min)

$$G = \text{geometry} = \frac{Physical\ Detector\ Area\ cm^2}{100}$$

GM physical detector area = 20 cm^2

ε_{Tot} = total efficiency = $\frac{counts}{disintegration}$ = ε_i x ε_s

ε_i = instrument efficiency

ε_s = source efficiency (unless otherwise determined: unless otherwise determined: 0.25 for β_{max} < 400 keV or 0.5 for β_{max} > 400 keV)

Other modifying factors = corrections for the attenuation effects of overlying materials, surface types, etc. that may be incorporated into a revised ε_s.

NOTE: The surface activity results for the individual detectors are evaluated to determine the homogeneity of the measured activity level in the assessed area. Elevated activity in a single detector is indicative of a hot spot that may require the activity level to be recalculated using an efficiency developed for localized areas of contamination. This determination will be made by the Site Coordinator.

6) Calculate the average surface activity for the pipe monitor total assessed area by substituting the following in the surface activity equation:

    a. N = the summed net count rate of the three individual detectors.

    b. ε_{Tot} = average total efficiency for the array.

    c. G = 1.68 (unless otherwise specified by the Site Coordinator for pipes with internal diameter larger than 4 inches).

Section 7.7 – Scanning with Global Positioning Systems

Purpose

To describe the recommended approach for collecting scan data using global position systems (GPS) with radiation detection instrumentation.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure.

List of Equipment

- ✓ Portable ratemeter: Model 2221 or Model 12, Ludlum Instrument Corporation; or equivalent, **enabled with RS-232 data collection capabilities**.
- ✓ Sodium iodide (NaI) detector: Model 489-55, Victoreen Instrument Co.; Model SPA-3 or Model PG-2, Eberline Instrument Corporation; or equivalent.
- ✓ Trimble GeoXH GPS Pocket PC unit, or equivalent, with Mobile OS and TerraSync software downloaded (periodic upgrades may be required).
- ✓ Cables: C-MHV; or other connectors, as applicable, for ratemeter-detector.
- ✓ Serial clip and coaxial cable with DB9 (female)/right-angle SMA connectors for connecting ratemeter to GPS unit.
- ✓ Carriage-style battery charger for GPS unit (Trimble P/N 53500-00).
- ✓ Zephyr antennae and range poles, optional.
- ✓ Stylus (for Pocket PC touch-screen entry).

Pre-Survey Considerations

- o Establish the geographic coordinate system to be used for the project (see Section 6.2 for more information). Determining factors might include matching the licensee or remedial contractor's choice of coordinate system which could minimize projection errors (if comparing locations is necessary) or by the acquisition of aerial maps that are already georeferenced.

- Consideration should be given in advance to survey methodology including:
  - Density of the scan coverage (typically based on survey unit classification),
  - Survey unit boundaries,
  - Potential obstacles such as inaccessible areas (trenches, piles, brush),
  - Satellite interference such as chain link fencing or large buildings which could shield signal reception,
  - Approach to investigation of "hotspots",
  - Documentation of other unanticipated factors (i.e., detector malfunction, etc.).

GPS Unit Setup

11. Assemble the ratemeter and detector and perform operational check-out procedures in accordance to Section 5.13.

12. Move to the starting point of the survey unit to be scanned (the GeoXH will begin collecting data as soon as the file is created).

13. Start the TerraSync software by either selecting the **GPS** hyperlink in the lower right corner of the screen <u>or</u> select **Start** from the upper left corner of the screen and then select **TerraSync** from the list provided. Attach an external antenna at this time, if desired.

14. If the default file name prefix has not already been set, do so at this time. Otherwise proceed to step 5. Tap the Section button, select **Setup** from the drop-down list, and then tap the **Logging Settings** button. Scroll down the list until the **Filename Prefix** line is visible. Using the Touch keyboard, enter the four digit task number assigned to the site.

15. Create a new file as follows: Tap the Section button and select **Data** from the drop-down list. Tap the Subsection button and select **New**. The **Filename** field should already contain the designated 4-digit task number (if not refer, to step 4), a two-digit month representation, a two-digit day representation, and a two-digit military hour representation. Additional descriptive text (e.g., C1SU5 for Class 1 Survey Unit 5 or Bldg2 for Building 2) may be added to more readily identify the area and/or surveyor initials.

    An audible beep will sound every one second to indicate data are being recorded.

Collecting Scan Data

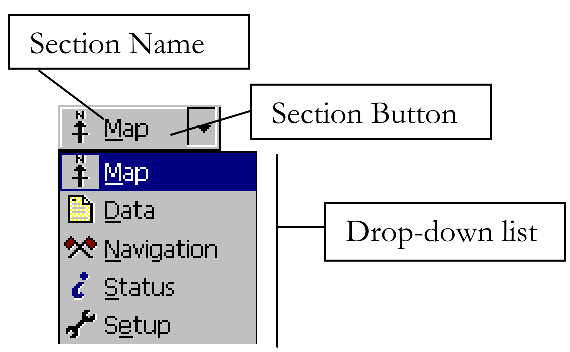
1. Walk over the area in the pattern and density determined from the Pre-Survey Considerations and/or from Section 7.1. Attention must be paid not only to instrument response but to satellite reception as well. Anything that blocks light also blocks satellite signals, such as people, buildings, heavy tree cover, large vehicles, fencing, or powerful transmitters. A trailing audible will occur when too few satellites are being received.

   There are planning tools available, if desired, such as the **Skyplot** (from the **Status** option of the Section button) which shows the optimal satellite availability at different hours throughout the day. To maximize data quality, the surveyor should attempt to follow these schedules or, if time constraints do not allow, make note of particular problem areas where full satellite coverage may not have been obtained.

2. Headphones with a stereo output connected to the ratemeter shall be worn for better audible response detection and improved surveyor efficiency.

3. The surveyor can switch between different views in the TerraSync software to see the instrument output (especially helpful if the instrument is being carried in a backpack) or the path traversed. Additionally, background files can be uploaded into the unit to provide georeferenced survey unit boundaries in open areas that may not have physical boundaries to reference.

   To set a background file, select **Map** from the Section button and then tap the Layers button just to the right of the Subsection button. Select **Background Files** from the list and choose the appropriate file. Files must have been prepared and transferred from the Pathfinder software to be available.



4. To view the path traversed or current location, tap the Section button and select **Map**.

5. To view the instrument output, tap the Section button and select **Status**. Then from the Subsection List, select **External Sensors.** The line labeled **Last String** will display the count rate equivalent to the instrument LED display.

6. After the area has been covered at the predetermined density, close the file. Tap the Section button, and then select **Data**. Tap the **Close** button and then click **OK** when asked for confirmation of closing the file.

7. Record any notes that may be necessary for data interpretation (i.e., NORM[1] (i.e., slag, granite, etc.), detector malfunctions, obstructions, etc.) in the project logbook and/or on forms.

Risk Mitigation

The reliance on electronic data capture comes with a certain amount of risk. The Site Coordinator is responsible for ensuring the data are protected. A backup system should be established in the event of system failure to minimize data loss. This will include daily data downloads to an external device such as an SDCard or handwriting data entry on printed forms. For specifics on data transfer methods, please consult the IEAV GIS Knowledge Base from the internal Sharepoint Site (no external access available).

Post-Processing Data

Although details will not be provided here, all data files will be post-processed using software with a differential correction utility (example, Pathfinder™). After data files have been post-processed they can be imported into mapping software, such as AutoDesk® Map 3D or ESRI® ArcView. For more information, refer to software instruction manuals or programmatic task guides/protocols.

[1] Naturally Occurring Radioactive Material.

Section 7.8 – Marking Sample Locations with Global Positioning Systems

Purpose

To describe the recommended approach for marking sample locations using global position systems (GPS). Radiation detection instrumentation may be used if measurement data are to be correlated with the sample location but is not required (the Site Coordinator will define project requirements).

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure.

List of Equipment

Required for documenting sample locations only:

- ✓ Trimble GeoXH GPS Pocket PC unit, or equivalent, with Mobile OS and TerraSync software downloaded (periodic upgrades may be required).
- ✓ Carriage-style battery charger for GPS unit (Trimble P/N 53500-00).
- ✓ Zephyr antennae and range poles, optional.
- ✓ Stylus (for Pocket PC touch-screen entry).

Additional equipment if measurement data are required:

- ✓ Portable ratemeter: Model 2221 or Model 12, Ludlum Instrument Corporation; or equivalent, **enabled with RS-232 data collection capabilities**.
- ✓ Sodium iodide (NaI) detector: Model 489-55, Victoreen Instrument Co.; Model SPA-3 or Model PG-2, Eberline Instrument Corporation; or equivalent.
- ✓ Cables: C-MHV; or other connectors, as applicable, for ratemeter-detector.
- ✓ Serial clip and coaxial cable with DB9 (female)/right-angle SMA connectors for connecting ratemeter to GPS unit.

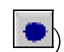
Data Collection

- Connect data acquisition instrumentation to the GPS unit if measurement data are required. No assembly is required if the GPS unit is to be used only for documenting sample locations.

- Start the TerraSync software by either selecting the **GPS** hyperlink in the lower right corner of the screen <u>or</u> select **Start** from the upper left corner of the screen and then select **TerraSync** from the list provided.

3. Create a new file as follows: Tap the Section button and select **Data** from the drop-down list. Tap the Subsection button and select **New** (it usually comes up as the default option so this step may not be necessary).

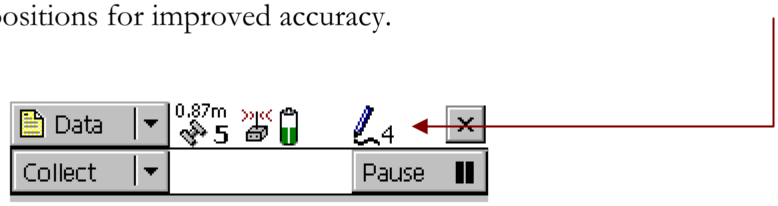
4. Enter a file name that contains the relevant 4-digit task number and describes the file as sample locations along with the survey unit or area designation.

5. Tap the **Create** button (denoted with a blue circle - ) in the upper right corner of the display screen.

6. Select the **Point_Feature** option to document sample locations.

7. A pop-up box will appear to **Confirm Antenna Height**. The triangulation required for accuracy is improved if the unit is placed on the ground at the sample location - enter 0 for the antenna height and tap the **OK** button. (For scanning the height should be entered as 1.0, see Section 7.7)

8. The unit will immediately start collecting data indicated by a pencil icon with an updating number indicating the number of collection points and an audible beep occurring at 1 second intervals. Collect at least 20 positions for improved accuracy.



TROUBLESHOOTING: If no audible is detected or if a message box displays that no positions were logged, consult the Terrasync Software Reference Manual for information on setting the Positional Dilution of Precision (PDOP) indicator for optimal quality.

Multiple locations may be marked within a file. To create additional locations, switch to **Map** mode (from the Section button). Click the **Create** button and while the positions are logging, enter the sample number in the **Comments** box.

9. **Alternatively,** pre-selected sample points may be uploaded into the GeoXH unit from text files created from a sample planning software application such as Visual Sample Plan, etc. For this method, the GPS unit will be used for **navigational purposes only**. For specifics on data transfer methods, please consult the IEAV GIS Knowledge Base from the internal Sharepoint Site (no external access available).

   Coordinates and other additional data such as measurements for sample points will be recorded either in ink on the appropriate form or recorded on an electronic text file

Risk Mitigation

The reliance on electronic data capture comes with a certain amount of risk. The Site Coordinator is responsible for ensuring the data are protected. A backup system should be established in the event of system failure to minimize data loss. This will include daily data downloads to an external device such as an SDCard or handwriting data entry on printed forms. For specifics on data transfer methods, please consult the IEAV GIS Knowledge Base from the internal Sharepoint Site (no external access available).

Section 7.9 – Job Hazard Analysis – Surface Scanning and Surface Activity Measurements

Discussion

Each survey site is unique and the specific hazards associated with media sampling vary from site-to-site. Normally expected hazards associated with these tasks are provided below together with standard controls.

JOB HAZARD ANALYSIS		
ACTIVITY	**HAZARD**	**CONTROL**
A. Surface Scanning	A1. Tripping	A1. Ensure field of view is unobstructed
	A2. Eye Injury	A2. Wear eye protection
	A3. Biological (Snakes, Ticks)	A3. Wear light colored clothing. Use insect repellant, or snake guards.
	A4.Puncture Wounds	A4. Clear or otherwise post hazardous debris areas; when clearing land, cut small brush parallel with and as close to the ground as practical; wear safety shoes
	A5. Vehicular Traffic	A5. Observe all traffic postings; wear safety vests; use spotters in high traffic, high noise areas
	A6. Radiation/ Contamination	A6. Minimize time in area once radiation in excess of detector capability is encountered; maximize distance; use PPE and/or engineering controls; monitor personnel for contamination

JOB HAZARD ANALYSIS		
ACTIVITY	**HAZARD**	**CONTROL**
B. Radiation Measurements	B1. Radiation/ Contamination	B1. Minimize time in area; maximize distance; use of engineering controls and/or PPE; monitor personnel for contamination
	B2. Biological	B2. Inspect measurement locations for hazards (spiders/snakes) prior to placing instruments in an area with an obstructed view, wear leather gloves as needed
	B3. Tripping	B3. Maintain field of view, mark or remove obstructions
	B4. Lifting	B4. Use proper lifting techniques
	B5. Falls (ladders/scaffolds/ mezzanines/man lifts)	B5. Properly incline support or tie-off ladders; use as appropriate railings, toe boards, body harnesses

Section 8.0

Sampling Techniques

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Section 8.1 – Surface Soil Sampling

Purpose

To describe the method for collecting samples of surface soil for routine radiochemical/radiophysical analysis.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Digging implement: garden trowel, shovel, spoons, post-hole digger, etc.
- ✓ Special sampling apparatus (cup cutter, Shelby tube, etc.) as required.
- ✓ Plastic bags, approximately 10 cm diameter x 30 cm long.
- ✓ Masking tape.
- ✓ Record forms and/or logbook.
- ✓ Labels and security seals.
- ✓ Indelible pen.
- ✓ Equipment cleaning supplies, as appropriate (see Section 4.5).

Sample Collection

NOTE: Because standard surface soil contamination criteria for radionuclides are usually applicable to the average concentration in the upper 15 cm of soil, the usual sampling protocol described here is based on obtaining a sample of this upper 15 cm. Special situations, such as to evaluate trends or airborne deposition, determining near surface contamination profiles, and measuring non-radiological contaminants, necessitate special sampling procedures. These special situations are evaluated and incorporated into site-specific survey plans as the need arises.

Direct surface and 1 meter gamma radiation measurements may be performed at each location before initiating sampling. This will identify the presence of gross radionuclide contamination which will require special handling and equipment cleanup procedures. Contact the Site Coordinator if the exposure rate measurement exceeds the capability of the instrumentation available on site before proceeding with sample collection. If contamination is suspected a beta-gamma "open" and "closed" measurement may also be desired before sampling begins.

1) Loosen the soil at the selected sampling location to a depth of 15 cm, using a trowel or other digging implement.

2) Remove large rocks, vegetation, and foreign objects (These items may also be collected as separate samples, if appropriate).

3) Place approximately 1 kg of this soil into a container sufficient to ensure moisture leakage and/or cross-contamination does not occur. If it is not possible to reach a depth of 15 cm using a hand tool (i.e. trowel or shovel) 1 kg of soil should be collected from the accessible depth. The actual depth should be recorded on the sample container and the data form.

4) Seal the sample container.

5) Label and secure the sample container in accordance with Section 8.15 and the chain-of-custody procedures in Section 8.16. Record pertinent information on the Chain-of-Custody Form (Figure B-16, or equivalent).

6) Record sample identification, location, and other pertinent data on appropriate record forms (Figures B-13, B-14, B-15, or equivalent), maps, drawings, and/or site logbook.

7) If the location has been identified as having elevated activity a measurement should be obtained after the sample is collected to determine the possibility of contamination at a depth greater than 15 cm. If a subsurface sample is deemed necessary, refer to Section 8.2.

8) Clean sampling tools, as necessary, before proceeding to the next sampling location, in accordance with instructions in Section 4.5.

Field Compositing of Samples

NOTE: The application of composite sampling is determined on a site-specific basis as designated in the survey plan or otherwise directed by the Site Coordinator (the latter requires documentation if it is a deviation from the survey plan). Data quality objectives for the project, analytical cost considerations, and special case site conditions are used to identify situations where sample compositing may be employed. Generally, five samples may be included in a composite with a maximum number of ten. The area represented by a composite sample will vary and should not exceed 100 m^2 unless specified otherwise in the survey plan or directed by the Site Coordinator (the latter requires documentation for the decision). Refer to the note in the Sample Collection section on page 2 of this procedure for applicable information related to sampling depths and measurements.

1) Collect equal aliquots of soil over 15 cm depth intervals from each location that will be included in the composite and place in bowl, on plastic sheeting or other type of containment.

2) Thoroughly mix sample and break up aggregates.

3) Divide soil into equal quadrants.

4) Place an equal aliquot (approximately 50 to 100 grams) from each quadrant into the sample container.

5) Repeat steps 3 and 4 a total of 3 times. Total sample amount collected should approximate 1 kg.

6) Proceed with steps 4 through 8 of the Sample Collection section on page 2 of this procedure.

Section 8.2 – Subsurface Soil Sampling

Purpose

To describe the method for collecting samples of subsurface soil.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Drilling equipment: drilling rig, portable motorized auger, manual auger.
- ✓ Subsurface sampling apparatus (split spoon, Shelby tube sampler, downhole sampler, (ORISE design) etc.).
- ✓ Plastic bags, approximately 10 cm diameter x 30 cm long.
- ✓ Trowel or spatula.
- ✓ Masking tape.
- ✓ Large rubber bands.
- ✓ Record forms and/or logbook.
- ✓ Labels and security seals.
- ✓ Indelible pen.
- ✓ Equipment cleaning supplies, as appropriate (see Section 4.5).

Sample Collection

When direct radiation measurements are required (surface and borehole logging), they are to be performed prior to sample collection in order to identify the presence of gross radionuclide contamination requiring special handling or cleanup (see Sections 4 and 10).

When a borehole fills with water and a water sample is desired refer to the groundwater sampling procedure in Section 8.4.

NOTE: Special considerations, such as those described for surface sampling, may require deviations from this procedure. These will be described in the site-specific survey plan as the need arises.

Systematic Subsurface Sampling (Option 1)

Procedures applicable to shallow boreholes, generally no greater than 2 to 3 meters in maximum depth

1) Assemble suitable auger (i.e. standard bucket auger or mud, sand, etc. augers) to extensions with "T" handle. Ensure depth demarcations are noted on the auger and extension handles.

2) Advance auger to each desired depth. Extract the auger to remove soil as the borehole is advanced. Direct monitoring should be performed and if contamination is suspected, decontaminate the auger between each sampling interval.

3) At the desired depth, remove the sample from the auger and transfer the sample to a container (plastic bag, plastic jar, etc.) and seal the container in a manner sufficient to ensure moisture leakage and/or cross-contamination does not occur.

4) Label and secure the sample container in accordance with Section 8.15 and the chain-of-custody procedures in Section 8.16. Record pertinent information on the Chain-of-Custody Form, (Figure B-16, or equivalent).

5) Record sample identification, location, depth, and other pertinent data on the appropriate record forms (Figures B-11, B-14, B-15, or equivalent), map, drawing, and/or site logbook.

6) Clean sampling tools, as necessary, before proceeding with further sample collection, in accordance with instructions in Section 4.5.

Systematic Subsurface Sampling (Option 2)

This procedure is applicable to depths of approximately 3 m when boreholes or trenches have been dug and remain uncollapsed or do not contain water.

NOTE: If borehole logging is to be, done it should be completed before sampling begins (see Section 7.2). If multiple samples are collected from a borehole, sampling is to be initiated at the deepest location and with subsequent samples collected at depths nearer to the surface. Prior to collecting samples, prepare the borehole wall at each sampling location by removing any soil that may have been potentially transferred from other depths.

7) Place a plastic bag liner into the downhole sampler and secure with a large rubber band.

8) Lower the sampling tool to the desired depth in the borehole or trench.

9) Scrape the inside borehole or trench wall with the toothed edge of the tool until approximately 1 kg of sample is collected.

10) Transfer the plastic bag and sample into container sufficient to ensure moisture leakage and/or cross-contamination does not occur.

11) Repeat steps 4 through 6 in the Option 1 section of this procedure.

Systematic Subsurface Sampling (Option 3)

This procedure is applicable to depths exceeding 3 m and in boreholes where walls do not remain intact or that fill with water.

1) Drill the borehole to the desired sampling depth using an auger.

2) Drive a split-spoon or shelby tube collector beyond the augered depth. The driving distance should be 30 to 60 cm.

3) Withdraw the collecting device and remove the collected core. Remove and appropriately discard the top 1 to 2 inches of the core as this material may represent soil that had collapsed into the borehole from other depths.

4) Place the core, or a portion of the core, into a container sufficient to ensure moisture leakage and/or cross-contamination does not occur. (The core may be split into multiple segments, representing different sampling depths).

5) Repeat steps 4 through 6 in the Option 1 section of this procedure.

Biased Subsurface Sampling

Procedures applicable when a surface sample has been collected and radiation levels are still elevated sufficiently above background as to require further investigation at the location.

1) Using a shovel, post-hole diggers, manual auger, drill rig, etc. collect 1 kg of the next 15 cm of soil and place into a container sufficient to ensure moisture leakage and/or cross-contamination does not occur. Care must be taken and sampling methods selected to ensure that soil that may have collapsed into hole from the surface is removed and not included in the subsurface sample.

2) Repeat steps 4 through 6 in the Option 1 section of this procedure.

3) Monitor the sample hole to determine activity level. If the activity level is still elevated, repeat steps 1, 2, and 3. . If the activity level has dropped to background, record the measurement and monitor the area, including personnel and equipment, to determine the extent of decontamination that may be necessary.

   NOTE: Immediately leave the area and contact the Site Coordinator and/or the appropriate site safety personnel if the exposure rate measurement exceeds the capacity of the instrumentation available on site.

Section 8.3 – Sediment Sampling

Purpose

To describe the method for collecting samples of sediment.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Digging implement: garden trowel, post-hole digger, etc.
- ✓ Thin-walled metal or plastic tube (Shelby tube).
- ✓ Ponar "clam-shell" dredge (with rope).
- ✓ Wide-mouth plastic bottle (approximately 1 liter size).
- ✓ Record forms and/or logbook.
- ✓ Labels and security seals.
- ✓ Indelible pen.
- ✓ Equipment cleaning supplies, as appropriate (see Section 4.5).

Sample Collection

NOTE: This procedure applies to the usual requirements for sediment samples for radiological contamination measurement. Special requirements other than those described below will necessitate other sampling procedures and considerations; these will be evaluated and described in detail in site-specific survey plans as the need arises.

Shallow Sediment Sampling

1) For shallow streams, wade into stream.
2) Facing upstream, use a collecting tool to obtain approximately 1 kg of sediment by scraping the material in an upstream direction.
3) Include all material collected - rocks and foreign objects can be discarded during sample preparation, as appropriate.
4) Alternatively, a shelby tube with an "egg shell" insert may be advanced into the sediment to obtain the sample.
5) The sample may be collected remotely from the stream bank, if water levels are too deep or the current is too strong for wading, by attaching extension handles to the collecting tool.
6) Proceed to Labeling section below.

Deep Water Sediment Sampling

1) Deep water sediment samples are collected using a Ponar dredge sampler or similar device.
2) Attach adequate length of rope to dredge.
3) Open dredge and insert locking bar into cut out on hinge.
4) Lower dredge at a rate of descent adequate to ensure penetration of the dredge into the sediment but without displacing lighter sediments.
5) Release tension on the rope to allow closure of dredge.
6) Retrieve dredge, decant excess liquids, open dredge and collect contents.
7) Proceed to Labeling section below.

Labeling

1) Place the sediment into a plastic bottle and tighten the screw cap.
2) Label and secure the sample container in accordance with Section 8.15 and the chain-of-custody procedures in Section 8.16. Record pertinent information on the Chain-of-Custody Form (Figure B-16 or equivalent).
3) Record sample identification, location, depth, and other pertinent information on the Miscellaneous Sample Record Forms (Figure B-17 or equivalent) and/or logbook.
4) Clean collecting equipment, as necessary, before proceeding with further sample collection, in accordance with instruction in Section 4.5.

Section 8.4 –Water Sampling

Purpose

To describe the method for collecting samples of water from surface and subsurface sources.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

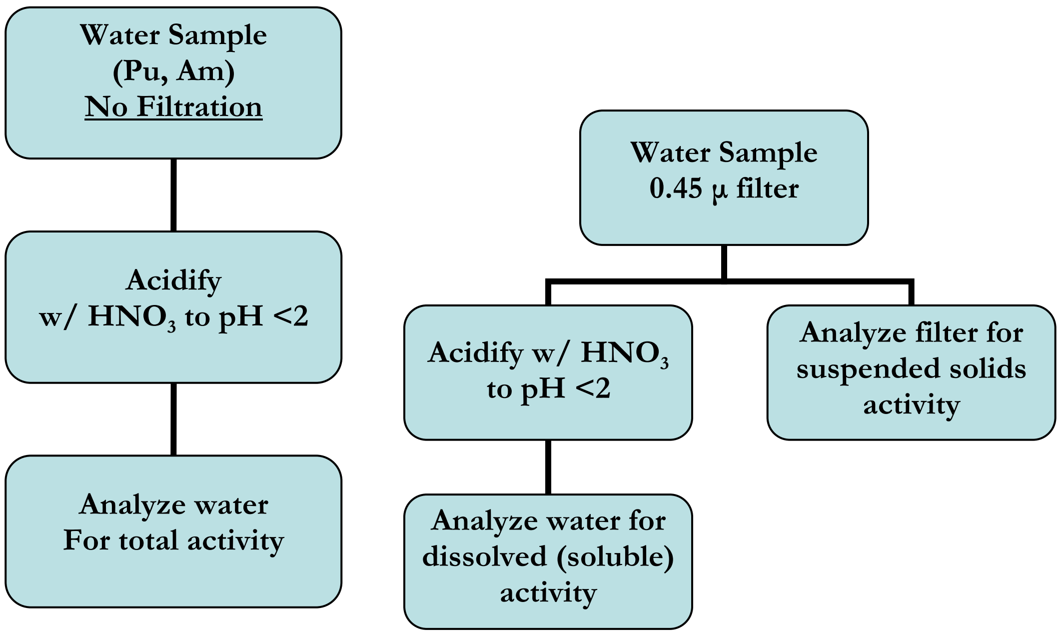
- ✓ Bailing implement: Borehole bailer (ORISE design), cup, can, pail, or other appropriate device.
- ✓ Submersible vacuum, or peristaltic pump with power source.
- ✓ Four liter plastic container, storage boxes and tags, or other container type as applicable.
- ✓ Funnel.
- ✓ Large Erlenmeyer flask with two-hole stopper.
- ✓ Tygon tubing.
- ✓ Record forms and/or logbook.
- ✓ Labels and security seals.
- ✓ Indelible pen.
- ✓ Equipment cleaning supplies, as appropriate (see Section 4.5).
- ✓ Sample preservatives, as appropriate.
- ✓ Filtering apparatus, as appropriate.

Sample Collection

Sample Filtering/Acidification

Field filtration or acidification is determined on a project-specific basis. The following flow chart is a guide for when each step is appropriate. Specific procedures will be provided in project-specific survey plans.

NOTE: If analysis for volatile radionuclides of concern such as H-3, C-14, Tc-99, or iodines will be required, other procedures may apply. The Laboratory Manager will provide specific requirements.



Surface Sample

1) Dip water carefully from the selected location or if using pump, insert collection tube into surface water being careful to avoid collection of bottom sediment or vegetation.
2) Using a funnel, transfer the water into a container or when using a pump discharge directly into sample container.
3) Collect a total of 3.8 liters of sample. Lesser amounts may be adequate, dependent upon analytical parameters.
4) Cap the container tightly.
5) Proceed to the Labeling section on the next page:

Groundwater (well or borehole) Sample (Option 1)

NOTE: If sampling from an established monitoring well, calculate the volume of the well and purge the well of three well volumes ($V = \pi r^2 h$). Collect purged water for appropriate handling. Monitoring of water quality parameters (i.e. dissolved oxygen, pH, eH, conductivity, temperature, etc.) may be required until parameters have stabilized ± 10% to ensure adequate purging. The necessary equipment for parameter monitoring is procured on a site-specific basis and operated in accordance with the manufacturer's instructions.

1) Lower the bailer apparatus into the borehole or other sub-surface source of water.
2) Allow water to flow into the bailer (use care to avoid buildup of sediments on the bailer diaphragm, which could prevent the diaphragm from sealing).
3) Retrieve the bailer and transfer contents into a container. If sampling for volatile organics, care must be taken to avoid aerating the sample (See Section 8.11).
4) Repeat until 3.8 liters or other specified volume of sample has been collected.
5) Proceed to the Labeling section below.

Groundwater Sample (Option 2)

1) Lower the inlet end of tubing until it contacts the water surface in a well or borehole or is located at the desired depth interval in a body of water.
2) Start pump and collect water directly into a flask or sample container, avoiding sample aeration.
3) Empty flask into container as necessary.
4) Repeat until 3.8 liters of sample or other appropriate volume has been collected.
5) Proceed to the Labeling section below.

Labeling

1) Label and secure the sample in accordance with Section 8.15 and the chain-of-custody procedure in Section 8.16. Record pertinent information on the Chain-of-Custody Form (Figure B-16 or equivalent).
2) The container should be placed in a cardboard box (also properly labeled) for better storage.

3) Record pertinent data on the Miscellaneous Sample Record Form (Figure B-17 or equivalent) and/or site logbook.

4) Clean collecting equipment, as necessary before proceeding with further sample collection, in accordance with instructions in Section 4.5.

   NOTE: When using a pump and tubing for sample collection, rinse tubing and pump (as applicable) with three volumes of deionized water.

Section 8.5 –Vegetation Sampling

Purpose

To describe the method for collecting samples of vegetation.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Knife, shears, or similar cutting tool.
- ✓ Plastic bags, medium size.
- ✓ Burlap bags.
- ✓ Masking tape.
- ✓ Baggage tags.
- ✓ Record forms and/or logbook.
- ✓ Labels and security seals.
- ✓ Indelible pen.
- ✓ Equipment cleaning supplies, as appropriate (see Section 4.5).

Sample Collection

1) Cut vegetation of desired type from selected location as close as possible to the surface. Alternatively, specific plant structures may be collected, dependent upon the survey scope. If the root system is collected, remove adhered soil by gently shaking. Any remaining soil will be removed in the laboratory.

2) Collect a total of approximately 1 kg of vegetation.

3) Place the sample in a plastic bag (if water is to be retained in the vegetation) or burlap bag (if vegetation is acceptable dry).

4) Secure the top of the bag with masking tape.

5) Attach a baggage tag.

6) Label and secure in accordance with Section 8.15 and the Chain-of-Custody procedures in Section 8.16. Record pertinent information on the Chain-of-Custody Form (Figure B-16 or equivalent).

7) Record all pertinent information on the Miscellaneous Sample Record Form (Figure B-17 or equivalent) and/or the site logbook.

8) Clean sampling equipment, as necessary, before proceeding with further sample collection in accordance with instructions in Section 4.5.

Section 8.6 –Air Sampling

Purpose

To describe the method for sampling airborne radioactive materials.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Commercial air sampler (HIVOL, Atomics, Andersen, etc.).
- ✓ Velometer or inclined manometer and Pitot tube.
- ✓ Sampling apparatus: pumps, pump housings, rotameter nozzles, tygon tubing, filters, filter housings, metal plates, probes, bubblers etc., as required.
- ✓ Petri dishes or other small containers.
- ✓ Tweezers.
- ✓ Masking tape, Teflon tape.
- ✓ Thermometer.
- ✓ Drill and appropriate size hole saw.
- ✓ Record forms and/or logbook.
- ✓ Labels and security seals.
- ✓ Indelible pen.
- ✓ Equipment cleaning supplies, as appropriate (see Section 4.5).

Sample Collection

The following describes the techniques, methods and considerations generally applicable to air monitoring surveys. Because specific procedures will depend upon many site conditions and parameters, this section should be viewed primarily as providing guidance to program personnel for planning purposes. Site specific procedures will be described in detail in survey plans.

Stack Sampling

1) Select a location in the stack for insertion of sampling probe. The optimum location to obtain isokinetic flow is a minimum of 8 stack diameters downstream and 2 diameters upstream from any transitions or bends in the stack. However, stack design may not allow the choice of sampling location by this criteria.

   NOTE: For certain facilities it may be necessary to use already existing probes or access points.

2) Drill (or hole saw) two 4 cm diameter access holes in the stack wall. These holes should be at approximately 90° angles to each other. Additional access holes may be required for stacks exceeding 0.75 m in diameter.

3) Using a Pitot tube and Alnor velometer or inclined manometer, perform duct traverses to determine the velocity distribution. Locations of measurements are in accordance with EPA Standard Method #1 as determined using the Stack Velocity Worksheet (Figure B-18 or equivalent). A minimum of 12 points are required for diameters > 0.61 m; 8 are required for diameters between 0.30-0.61m. Record all measurements.

4) Measure temperature and, if appropriate, moisture content of stack gases.

5) Calculate appropriate nozzle diameter sizes and flow rates for isokinetic sampling, using the Stack Sampling Rate Worksheet (Figure B-19 or equivalent). Nominal sampling rates will be determined by the sample collection system design; these rates typically range from 5 to 30 L/min.

   NOTE: The collection system selected will be specific for the stack conditions and contaminants of interest. Because of the wide variety of possibilities which may be encountered, there is no attempt in this procedure to address specific or individual systems. Such matters are addressed in detail in site specific survey plans.

6) Attach nozzles and secure plates to probe tubes.

7) Adjust nozzle location (sample tip to plate assembly distance) to the desired sampling position.

8) Insert nozzle the appropriate measured distance into stack with nozzle opening in direct alignment with stack air flow.

9) Secure metal plates against stacks with rope or bungee cords.

10) Place one probe at a fixed location, usually in the same approximate location as the site's sample probe; reposition a second probe periodically to various predetermined sampling locations within the stack.

11) Start pump and adjust needle valves to obtain the desired flow rate.

12) Test system for leakage by blocking intake or pinching hose near intake. If flow rate does not drop to <10% of the initial (unblocked) rate, re-check and tighten connections and components until the system is leak tight.

13) Note and record starting time and flow.

14) During initial sampling, periodically (every 2-4 hours) check the system to assure that the desired sampling rate is being maintained. Make flow rate adjustments or changes in collection system as necessary. Record on the Stack Sampling Record Form (Figure B-20 or equivalent).

15) Turn pump off at the previously determined time. Record final time and flow rate.

16) Transfer sample collection media to appropriate containers and label in accordance with Section 8.15 and the chain-of-custody procedures in Section 8.16. Record pertinent information on the Chain-of-Custody Form (Figure B-16 or equivalent).

17) Clean equipment before initiating further sampling.

18) When sampling is complete, remove probe assemblies, and insert expansion plug into stack access hole, if appropriate.

Sampling Ambient Air

1) Select sampling location, based on objective of sampling.

2) Select collection media or system, based on contaminants of interest and ambient atmospheric conditions (see NOTE at the bottom of page 2 of this procedure).

3) Assemble collection system, flow measuring device, and vacuum system. Record pertinent information on the Field Air Sampling Data Sheet (Figure B-23 or equivalent).

4) Test system for leakage by blocking intake or pinching hose near intake. If flow rate does not drop to <10% of the initial (unblocked) rate, re-check and tighten connections and components until the system is leak tight.

5) Note and record starting time and flow.

6) During initial sampling, periodically (every 2-4 hours) check the system to assure that the desired sampling rate is being maintained. Make flow rate adjustments or changes in collection system as necessary. Record on the Stack Sampling Record Form (Figure B-20 or equivalent).

7) Turn pump off at the previously determined time. Record final time and flow rate.

8) Transfer sample collection media to appropriate containers and label in accordance with Section 8.15 and the chain-of-custody procedures in Section 8.16. Record pertinent information on the Chain-of-Custody Form (Figure B-16 or equivalent).

9) Clean equipment before initiating further sampling.

Section 8.7 –Determination of Removable Activity

Purpose

To provide guidelines for measuring removable alpha and beta radioactivity on equipment and building surfaces.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Filter papers (Whatman 50 or equivalent), 47 mm diameter, numbered.
- ✓ Glassine or paper envelopes.
- ✓ Record forms and/or logbook.
- ✓ Counting equipment.
- ✓ Indelible pen.
- ✓ PPE, rubber gloves.

Sample Collection

<u>Gross Alpha and Gross Beta Smear</u>

NOTE: Direct measurements should be completed before a smear sample is taken.

1) Grasp the smear (filter) paper by the edge, between the thumb and index finger.

2) Applying moderate pressure with two or three fingers, wipe the numbered side of the paper over approximately 100 cm^2 of the surface.

3) Place the filter in an envelope.

4) Record the smear number, site, date, location of the smear, and name of sample collector on the envelope.

5) Label and secure the sample in accordance with Section 8.15 and the chain-of-custody procedure in Section 8.16. Record pertinent information on the Chain-of-Custody Form, (Figures B-9, B-12, or equivalent).

6) If the initial direct measurement was elevated, the smear should be monitored to determine whether contaminated material was transferred to the smear. If an activity level greater than 250 cpm is detected, the smear envelope should be marked as such.

   NOTE: Smears having activity levels greater than 2500 cpm should be counted using field instrumentation and should be sealed in an appropriate container and marked to minimize potential for cross-contamination.

Low-Energy Beta Smear

1) If the survey objective is to determine if low-energy beta-emitters (such as C-14 or H-3) are present, an additional smear may be collected.

2) Pre-fill the appropriate number of scintillation vials with deionized water to approximately one-half volume.

3) Moisten the numbered side of a smear with deionized water from a scintillation vial.

7) Grasp the smear (filter) paper by the edge, between the thumb and index finger.

4) Applying moderate pressure with two or three fingers, wipe the numbered side of the paper over approximately 100 cm^2 of the surface.

5) Gently roll the smear to the approximate diameter of the opening of the vial with the numbered side facing out and place the smear inside the scintillation vial. Replace the cap.

6) A field blank should be prepared by placing an unused smear into a scintillation vial containing the deionized water used to moisten the smears.

7) Label and secure the sample in accordance with Section 8.15 and the chain-of-custody procedure in Section 8.16. Record pertinent information on the Chain-of-Custody Form, (Figures B-9, B-12, or equivalent).

8) If the initial direct measurement was elevated, the smear should be monitored to determine whether contaminated material was transferred

to the smear. If an activity level greater than 250 cpm is detected, the smear envelope should be marked as such.

Field Sample Measurement

1) If the survey objective is to determine if radon or thoron daughter products or other short half-life radionuclides are present, the smears should be counted within 1-2 hours before significant decay of short-lived radionuclides has occurred.

2) If necessary, smears can be counted in the field using portable instrumentation (see Section 7).

3) Record count and counting time data on the appropriate record form (Figure B-9, B-12, or equivalent).

4) Determine the net count rate (N) by subtracting the background count (determined by counting a blank or unused smear) from the gross count rate.

$$N\ cpm = \frac{Gross\ Count - Background\ Count}{Time}$$

5) Substitute the value for N in the surface activity equation in Sections 7.3 and 7.4 for calculating the removable activity. Note whether the detector is monitoring for alpha, beta, or alpha plus beta. The value for geometry (G) will be 1, provided a 100 cm^2 area was wiped.

Section 8.8 – Miscellaneous Sampling

Purpose

To describe methods for collecting miscellaneous samples.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

Equipment is chosen based on the type of material to be sampled. The following list represents some possibilities:

- ✓ Paint sampling – heat gun, paint stripper solution, chisel and hammer.
- ✓ Drains or pipes – plumber's snake and swabs.
- ✓ Residues – trowels, scoops.
- ✓ Concrete or asphalt – core borers, hammer and chisel.
- ✓ Record forms.

Sample Collection

Methods for collecting miscellaneous samples should be determined based on the characteristics of the sample media and the data quality objectives. Care should be taken to limit the potential for spreading contamination during sample collection.

Sample quantities should be determined based on the following:

- Type of analyses required
- Number of analyses to be requested
- Detection sensitivity required of analytical result
- Estimated activity level of material

Label and secure all samples in accordance with Section 8.15 and the chain-of-custody procedure in Section 8.16. Record pertinent information on the Chain-of-Custody and Miscellaneous Sampling Measurement Record Forms (Figures B-16, B-17, or equivalent).

Section 8.9 – Surface Soil Sampling for Chemical Analysis

Purpose

To describe the procedures for collecting samples of surface soils for chemical analysis.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure.

List of Equipment

- ✓ Trowel, shovel, or other digging implement.
- ✓ Stainless steel or Teflon-lined scoop or spoon (prepared as specified in 8.13)
- ✓ Visqueen sheets.
- ✓ Wide mouth glass sample jars with Teflon-lined closures or other appropriate container (normally provided by the analytical laboratory).
- ✓ Sample shipment containers, packing material, and ice or "blue ice".
- ✓ Sample equipment decontamination supplies (described in Section 8.14).
- ✓ Sample gloves.
- ✓ Labels and security seals.
- ✓ Record forms and/or logbook.
- ✓ Check source.

Sample Collection

NOTE: This is a general procedure to utilize for obtaining soil samples from the surface to a maximum depth of 15 cm. Specific environmental contaminants of interest may require a modification to parts of this procedure. Variances to this procedure will be addressed and incorporated into the site-specific survey plan.

Sampling for volatile organic compounds (VOCs) or derivations thereof (non-halogenated VOCs, SVOCs), will likely require special sample containers, collection methods and preservation methods. Consult with the analytical laboratory during the development of the site-specific sampling plan to determine appropriate requirements.

General guidance for sampling of VOCs may be found in Section 12 of the EPA *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual*, available at http://www.epa.gov/region4/sesd/eisopqam/eisopqam.pdf.

The following sampling procedure is generally appropriate for metals, PCBs, dioxins, furans, and most non-VOC chemical contaminants in soil. Guidance for other chemical contaminants or analysis methods may be found at the EISOPQAM link above, or in EPA SW-846 at http://www.epa.gov/sw-846/main.htm.

General Sampling Procedure

1) Stage sampling equipment onto clean visqueen sheets in order to prevent contamination of equipment by contact with the ground.

2) With the trowel or shovel, remove surface vegetation and other debris that may interfere with sample collection as well as any overburden to access the desired sample location and depth.

3) With the spoon or scoop, remove any soil that may have come in contact with the trowel, shovel, etc. Then collect the appropriate volume of sample and place into the sample container (if sample is a known hazardous waste, do not exceed sample container size of 16 oz or more than 1 lb of sample including container). The survey plan will specify the container type.

4) Label and secure sample container in accordance with Section 8.15 and the chain-of-custody procedures in Section 8.16. Record pertinent information on the Chain-Of-Custody Form (Figure B-16 or equivalent).

5) Record sample identification, location, date, time, and other pertinent data on field work forms, maps, drawings, and /or site logbook.

6) Clean off sample container, place in zip lock bag, and package in shipping cooler with ice or blue ice. The samples shall be maintained at a temperature of approximately 4 degrees Celsius until received by the analytical laboratory.

7) Clean trowel, etc. and use new spoon or scoop for next sample or if necessary, decontaminate in accordance with Section 8.14.

8) Change sample gloves prior to collection of next sample.

9) Ship the samples to the analytical laboratory and assure receipt within one week of collection.

Table 2. Summary of chemical sample collection requirements

Contaminant of Concern	Container	Preservation Method	Procedural Holding Time	Maximum Holding Time
PCB	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	14 days
Dioxin/Furan	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	30 days
Metals	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	180 days
Chromium +6	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	28 days
Mercury	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	28 days
VOCs	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	Dependent on container type.
SVOCs	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	Dependent on container type.
Non-halogenated VOCs	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	Dependent on container type.

Section 8.10 – Subsurface Soil Sampling for Chemical Analysis

Purpose

To describe the procedures for collecting samples of subsurface soils for chemical analysis.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure.

List of Equipment

- ✓ Drilling equipment: hand auger, motorized auger, drill rig, etc. Cleaned and prepared as described in Section 8.13.
- ✓ Sampling equipment: split-spoon, shelby tube, trier, stainless steel or teflon spoon, etc. Prepared as described in Section 8.13.
- ✓ Visqueen sheets.
- ✓ Wide mouth glass sample jars with Teflon-lined closures or other appropriate container (normally provided by the analytical laboratory).
- ✓ Sample shipment containers, packing material, and ice or "blue ice".
- ✓ Sample equipment decontamination supplies (described in Section 8.14).
- ✓ Sample gloves.
- ✓ Labels and security seals.
- ✓ Record forms and/or logbook.

Sample Collection

NOTE: This is a general procedure for obtaining subsurface soil samples. Specific environmental contaminants of interest may require a modification to parts of this procedure. Variances to this procedure will be addressed and incorporated into the site-specific survey plan.

Sampling for volatile organic compounds (VOCs) or derivations thereof (non-halogenated VOCs, SVOCs), will likely require special sample containers, collection methods and preservation methods. Consult with the analytical laboratory during the development of the site-specific sampling plan to determine appropriate requirements.

General guidance for sampling of VOCs may be found in Section 12 of the EPA *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual* (EISOPQAM), available at http://www.epa.gov/region4/sesd/eisopqam/eisopqam.pdf.

The following sampling procedure is generally appropriate for metals, PCBs, dioxins, furans, and most non-VOC chemical contaminants in soil. Guidance for other chemical contaminants or analysis methods may be found at the EISOPQAM link above, or in EPA SW-846 at http://www.epa.gov/sw-846/main.htm.

General Sampling Procedure (Option 1)

1) Stage all drilling and sampling equipment onto clean visqueen sheets in order to prevent contamination of equipment by contact with the ground.

2) Drill borehole to the required sampling depth.

3) Lower a sidewall scraper to the required sampling depth (sampling should be initiated at the maximum sample depth and proceed toward the surface) and scrape away the initial layer of soil that was in contact with the drilling equipment. This is to remove any contamination spread by the drill.

4) Lower the sampling tool to the sample point and collect sample.

5) Transfer sample to appropriate container, and seal the sample container. The survey plan will specify the container type.

6) Label and secure sample container in accordance with Section 8.15 and the chain-of-custody procedures in Section 8.16. Record pertinent information on the Chain-Of-Custody Form (Figure B-16 or equivalent).

The samples shall be maintained at a temperature of approximately 4 degrees Celsius until received by the analytical laboratory.

7) Record sample identification, location, date, time, and other pertinent data on field work forms, maps, drawings, and /or site logbook.

8) Use a clean sampling device for the next sample location or decon equipment in accordance with Section 8.14.

9) Change sample gloves prior to collection of next sample.

10) Ship the samples to the analytical laboratory and assure receipt within one week of collection.

Subsurface Soil Sampling (Option 2)

1) Stage equipment on visqueen sheeting.

2) Drill or auger borehole to the required depth.

3) Drive a split spoon sampler, shelby tube, or other coring device beyond the borehole depth.

4) Remove the collecting device, discard the top 1 to 2 inches of core, and remove the remaining core.

5) Place the core or segments representing specific sample depths into appropriate container(s). The survey plan will specify the container type.

6) Label and secure sample container in accordance with Section 8.15 and the chain-of-custody procedures in Section 8.16. Record pertinent information on the Chain-Of-Custody Form (Figure B-16 or equivalent). The samples shall be maintained at a temperature of approximately 4 degrees Celsius until received by the analytical laboratory.

7) Record sample identification, location, date, time, and other pertinent data on field work forms, maps, drawings, and /or site logbook.

8) Use a clean sampling device for the next sample location or decon equipment in accordance with Section 8.14.

9) Change sample gloves prior to collection of next sample.

10) Ship the samples to the analytical laboratory and assure receipt within one week of collection.

Subsurface Soil Sampling (Option 3)

1) Open a trench to the specified depth with backhoe or trackhoe excavator or utilize existing trench.

   NOTE: OSHA requirements must be met before working in a trench.

2) Follow procedure for Sample Collection specified in Section 8.9 at each required sample depth.

Table 3. Summary of chemical sample collection requirements

Contaminant of Concern	Container	Preservation Method	Procedural Holding Time	Maximum Holding Time
PCB	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	14 days
Dioxin/Furan	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	30 days
Metals	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	180 days
Chromium +6	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	28 days
Mercury	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	28 days
VOCs	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	Dependent on container type.
SVOCs	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	Dependent on container type.
Non-halogenated VOCs	As provided by analytical lab	Cool to 4 degrees C	As directed by analytical lab.	Dependent on container type.

Section 8.11 – Surface Water and Groundwater Sampling for Chemical Analysis

Purpose

To describe the procedures for collecting samples of surface water and groundwater for chemical analysis.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Dipper: constructed from a telescoping pole and a stainless steel, teflon or glass beaker attached to the pole with a clamp. Cleaned as specified in Section 8.13.
- ✓ For sampling at specific depths: Weighted bottle or peristaltic pump equipped with teflon and tygon tubing, teflon or stainless steel bailer, or other appropriate equipment. Tubing cleaned as specified in Section 8.13.
- ✓ Sample containers: analytical parameter specific as to type (typically a 3.8 liter amber glass bottle with teflon lined cap). Containers must be prepared as described in Section 8.13 or otherwise specified in the site-specific survey plan.
- ✓ Visqueen sheeting.
- ✓ Sample preservatives: Analytical parameter specific, specified site-specific survey plan.
- ✓ Sample shipment container packing materials, ice or "blue ice".
- ✓ Miscellaneous test equipment as needed. Water quality meter, vacuum filter, pipettes, etc.
- ✓ Sample equipment decontamination supplies (described in Section 8.14).
- ✓ Labels and security seals.
- ✓ Record forms and/or logbook.

Sample Collection

For sampling water at the surface, carefully lower dipper into the water and withdraw a sample. Care must be taken to avoid aerating the sample during sampling and handling if the analytical parameters include volatile organics.

If the sampling plan includes depth samples, then either a pump or a weighted bottle may be used to retrieve samples from a specific depth.

Weighted Bottle Sampling

1) Attach line marked with depth indicators to the weighted bottle
2) Lower the bottle to the desired depth and remove stopper using the manual release mechanism.
3) Fill the bottle, retrieve sample, and transfer to the appropriate sample container.
4) Proceed to Labeling and Decontamination on the next page.

Peristaltic Pump Depth Sampling

1) Mark off teflon tubing to indicate the depth intervals.
2) Attach inlet tubing to a two hole stopper by means of glass tubing and teflon connectors which is fitted to a sample collection flask or sample bottle. Outlet port from stopper is fitted with glass tubing. Attach tygon tubing at this point and fit to pump.
3) Collect sample. If sample preservatives are required, they should be added to the sample container at this time.
4) Pour sample into the sample container. Tilt sample bottle and pour sample slowly down the inside wall in order to avoid aeration. The sample filtering procedures, when required, will be discussed in the site-specific survey plan.
5) Replace tubing between each sample.
6) Record sample identification, location, date, time, and other pertinent data on field work forms, maps, drawings, and /or site logbook.
7) Use a clean sampling device for the next sample location or decon equipment in accordance with Section 8.14.
8) Change sample gloves prior to collection of next sample.
9) Proceed to Labeling and Decontamination on the next page.

Groundwater Sampling (Option 1)

NOTE: If sampling from an established monitoring well, calculate the volume of the well and purge the well of three well volumes ($V=\pi r^2 h$). Collect purged water for appropriate handling. Monitoring of water quality parameters (i.e., dissolved oxygen, pH, eH, conductivity, temperature, etc.) may be required until parameters have stabilized ± 10% to ensure adequate purging. The necessary equipment for parameter monitoring is procured on a site-specific basis and operated in accordance with the manufacturer's instructions.

1) Lower the bailer apparatus into the borehole or other sub-surface source of water.

2) Allow water to flow into the bailer (use care to avoid buildup of sediments on the bailer diaphragm, which could prevent the diaphragm from sealing).

3) Retrieve the bailer and transfer contents into a container. If sampling for volatile organics, care must be taken to avoid aerating the sample.

4) Repeat procedure until 3.8 liters or other specified volume of sample has been collected. The sample filtering procedures, when required, will be discussed in the site-specific survey plan.

5) Proceed to the Labeling and Decontamination section listed above.

Groundwater Sampling (Option 2)

1) Lower the inlet end of tubing until it contacts the water surface.

2) Start pump and collect water directly into sample container, avoiding sample aeration.

3) Empty flask into container as necessary.

4) Repeat until 3.8 liters of sample or other appropriate volume has been collected. The sample filtering procedures, when required, will be discussed in the site-specific survey plan.

5) Proceed to the Labeling and Decontamination section listed on the previous page.

6) Change sample gloves before proceeding with next sample.

Labeling and Decontamination

1) Label and secure the sample in accordance with Section 8.15 and the chain- of-custody procedures in Section 8.16. Record pertinent information on the Chain-of-Custody Form (Figure B-16 or equivalent).

2) Record sample identification, location, depth, date, time, and other pertinent data on field work forms, maps, and/or logbooks.

3) Use a clean sampling device for the next sample location or decontaminate equipment in accordance with Section 8.14.

4) Change sample gloves before proceeding with next sample.

Section 8.12 – Swab Surface Sampling for Chemical Analysis

Purpose

To describe the procedures for collecting samples from non-porous surfaces for chemical analysis.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Swabs for sampling: sterile cotton gauze pads or similar type pad.
- ✓ Two containers of extractant: analytical parameter specific; generally solvent or dilute acid prepared prior to mobilization and stored in a properly cleaned glass or teflon container as specified in Section 8.13.
- ✓ 10 cm x 10 cm disposable templates.
- ✓ Sample holding container: Small, wide mouthed glass jar with teflon lined closure.
- ✓ Plastic Zip-loc bags.
- ✓ Sample shipment container packing materials, ice or "blue ice".
- ✓ Forceps.
- ✓ Rubber gloves.
- ✓ Sample equipment decontamination supplies (described in Section 8.14).
- ✓ Labels and security seals.
- ✓ Record forms and/or logbook.

Sample Collection

NOTE: Prior to mobilization, a sufficient number of sampling kits should be assembled. Each kit should be compiled into a zip-lock bag and contain the following items: one prepackaged swab, sample holding container.

1) Unwrap swab from package, place in forceps, and soak with extractant. Press out excess liquid inside of sample container.

2) Hold template at sample point.

3) With one side of the swab, completely wipe the sample area with a vertical overlapping pattern.

4) Turn the swab over and completely wipe the sample area with a horizontal overlapping pattern.

5) Place the swab into the sample container, label, and secure sample container in accordance with Section 8.15 and the chain-of-custody procedures in Section 8.16. Record pertinent information on the Chain-of-Custody Form (Figure B-16 or equivalent).

6) Record sample identification, location, date, time, and other pertinent data on miscellaneous Sample Record Forms (Figure B-17 or equivalent), maps, and/or logbook.

7) Prior to taking next sample, change sample gloves and rinse forceps in a separate container of extractant than the one used for soaking the swabs in order to prevent cross contamination Attach line marked with depth indicators to the weighted bottle.

Section 8.13 – Equipment Preparation for Chemical Sampling

Purpose

To prepare clean and contaminant free sampling equipment for use during field chemical sample collection projects

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Cleaning solutions: Non-phosphate laboratory-grade detergent.
- ✓ Brushes.
- ✓ Tap water.
- ✓ Deionized water.
- ✓ Solvent (isopropanol or other specified solvent).
- ✓ Aluminum foil, Teflon-coated contact sheets, visqueen sheets.

Equipment Cleaning

NOTE: This is the general procedure to follow. Analytical requirements for certain environmental contaminants require a modification of this procedure. These special requirements will be addressed in the site-specific survey plan.

1) Thoroughly scrub equipment with detergent and tap water.
2) Rinse thoroughly with tap water.
3) Rinse thoroughly with deionized water.
4) Rinse equipment twice with solvent. Collect solvent for appropriate reuse or disposal.
5) Place equipment on sheets of aluminum foil, teflon coated adhesive sheets, or visqueen sheets for larger equipment and allow to air dry for 24 hours in a clean, uncontaminated area.
6) Wrap equipment in aluminum foil (or visqueen for large equipment) and store or transport to the field.

Section 8.14 – Field Decontamination of Chemical Equipment

Purpose

To describe the procedures for field decontamination of sampling equipment to prevent cross contamination of samples.

NOTE: It is preferred that sufficient pieces of equipment are taken to the field so that this process is not necessary. However, for large or specialized pieces of equipment and/or large projects this is a necessary and acceptable procedure.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ 35 gallon carboys for storage of cleaning solutions.
- ✓ Cleaning tubs for collection of used solutions.
- ✓ Brushes.
- ✓ Laboratory-grade, non-phosphate grade detergent.
- ✓ Tap water.
- ✓ Deionized water.
- ✓ Isopropanol or other solvent(s) as required.
- ✓ D.O.T.-approved 55 gallon drum for storage of rinsates when required.
- ✓ Aluminum foil and/or visqueen sheets.

Equipment Cleaning

NOTE: This is a general sampling equipment field decontamination procedure. When sampling for certain contaminants, this procedure may require modification. Special situations will be addressed in the site-specific survey plan.

Equipment Cleaning (cont'd)

1) Brush gross residue off of the sampling implement and rinse with tap water (rinse water may require collection and proper disposal).
2) Clean equipment with laboratory grade detergent.
3) Rinse thoroughly with tap water. Collect rinse water when required.
4) Rinse with deionized water. Collect deionized water rinsate when required.
5) Rinse twice with solvent. Collect solvent for proper disposal.
6) Allow equipment to air dry as long as possible before reuse.
7) If equipment is not reused the same day wrap in aluminum foil or visqueen sheets for large equipment and store in a contaminant free zone.

Section 8.15 – Sample Identification and Labeling

Purpose

To provide a uniform system for identifying and labeling samples.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.

- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Samples, in appropriate containers.
- ✓ Indelible pen.
- ✓ Preprinted form labels, if desired.

Identification and Labeling

1) Identify each sample (with the exception of individual smears) by an alpha-numeric code as follows:

    a. The first three or four numeric characters are the predetermined project number for the facility, site, or task. If the first number of the project number is "0", it is not necessary to include the "0" in the sample identification.

    b. The next character designates the sample matrix:

    S — SOIL (e.g., systematic, biased, borehole, sediment, sludge

    W — WATER (e.g., from a borehole, stream, well)

    M — MISCELLANEOUS (e.g., includes air, vegetation, and any others not defined in this procedure.

    R — SMEARS

    NOTE: Smear samples are grouped and assigned sample identification numbers according to requirements for analytical batch set-up.

c. The last three numeric characters indicate the sequential number for a sample of a particular matrix. Each number will correspond to a location designation on a map or grid area.

d. Examples:

- 123S050 is the 50th soil sample collected during project number 0123.

- 123W006 is the 6th water sample collected during project number 0123.

- 1200M010 is the 10th miscellaneous sample collected during project number 1200.

- 1620R001 is the first batch of smears in project number 1620. This batch will probably contain multiple smears, usually limited to 100. However, the individual smear envelope labels will correspond with the numbered smear (the site number is noted on a separate line). Additional smears collected above 100 will have a sequential alphabetic character, starting with "A" (e.g., 1A-100A, 1B-100B, etc.), assigned after the corresponding smear number.

- Quality assurance and background samples will be distinguished in "Location" or "Remarks" columns of the field data sheets.

- Borehole samples will be numbered consecutively. Sample depth must be noted on field data sheet and sample container.

2) Enter the identification code, grid reference points, sample collection depth, date of sampling, sampler initials, and other pertinent information on the appropriate forms and on the sample container. For miscellaneous samples, specify the material on the form.

3) Mark the container using an indelible pen.

4) Place all samples known or suspected of containing levels of radioactivity, which could present a contamination or exposure problem in the field or laboratory, in clean outer containers and clearly mark any explanatory information, as appropriate, according to the sample screening requirements (See Section 4).

Section 8.16 – Sample Chain-of-Custody

Purpose

To provide and maintain sample accountability and integrity.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.

- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Samples, in appropriate containers.
- ✓ Indelible pen.
- ✓ Chain-of-Custody forms.

Initiation of Sample Custody

1) Chain-of-custody forms must be prepared daily.

2) A sample collector assumes responsibility as custodian and initiates a chain-of-custody form in duplicate.

3) The sample(s) must be under direct surveillance of the sample custodian, secured in a locked vehicle or building, or in a tamper-proof container at all times.

4) Each sample may be listed on the chain-of-custody form separately or a group of samples having common characteristics from a single site may be recorded as a single entry using a sample identification number range. If an item is not applicable "NA" is entered.

5) Samples collected by other organizations that are provided to field personnel will have chain-of-custody initiated for them by the individual receiving the samples. When the organization has an established chain-of-custody in place, a copy of the form will be attached to the ORISE form.

Transfer of Custody

1) Samples are inspected prior to custody transfer to determine any evidence of tampering. Evidence of tampering and/or any deviations must be explained in the "Remarks" section of the form. If sample integrity is questionable for any reason, a nonconformance report will be initiated, including, as part of the corrective action plan, determination of the effect on the usefulness of the analytical data.

2) Sample custody is transferred by the custodian signing the "Relinquished By" block and the receiver signing the "Received in Good Condition By" block.

Security and Transport

1) Sample security seals may be placed on the container of samples to ensure container is tamper-proof. The number of the seal must be entered on the chain-of-custody form. Numbered seals may be replaced by tape with the samplers or custodians initials.

   NOTE: Containers with security seals do not have to remain in a secured area but precautions should be taken to restrict access to the samples to authorized individuals.

2) The original (white copy) of the chain-of-custody form must contain all signatures and other pertinent records regarding custody. Therefore, the original is retained in the possession of the individual who has custody at any specific time.

3) As long as samples remain with the custodian, both copies of the Chain-of-Custody Form are to accompany the samples.

4) When shipping samples ahead of the custodian, the white copy of the chain-of-custody record must be signed and mailed to the ORISE Laboratory Manager or designee. The yellow copy accompanies the samples.

Laboratory Sample Custody

1) The Laboratory Manager or designee will inspect sample container and contents for tampering, compare to original chain-of-custody form, note any deficiencies in the remarks column, and sign form to accept custody.

2) Sample information is entered into the sample database.

3) Samples remain in the Laboratory Manager's or designee's custody. White copy of form is kept in the laboratory file; yellow copy is kept in the project file.

4) During analysis, the samples will remain in a locked building during working hours and in a locked room in the building during non-working hours.

Sample Archival and Disposal

1) Samples are considered active until disposed, consumed, transferred, or destroyed.

2) Archived samples are stored in a locked building with limited access.

3) Sample disposal must be approved by the agency/customer.

Section 8.17 – Job Hazard Analysis – Sampling

Discussion

Each survey site is unique and the specific hazards associated with media sampling vary from site-to-site. Normally expected hazards associated with these tasks are provided below together with standard controls.

Soil Sampling

JOB HAZARD ANALYSIS		
ACTIVITY	**HAZARD**	**CONTROL**
A. Soil Sampling	A1. Back Injury	A1. Use proper lifting techniques when carrying quantities of samples, use proper ergonomics when digging samples
	A2. Radiation/ Contamination	A2. Use disposable gloves and protective clothing when collecting samples known or suspected to contain high activity levels, minimize sample contact, label sample in accordance with procedures, monitor personnel and equipment for contamination
	A3. Pinch points	A3. Wear leather gloves and safety shoes.
	A4. Eye injury	A4. Wear eye protection when using picks or similar devices to loosen soil
	A5. Fire	A5. When using gas powered auger, maintain fire watch whenever fueling or otherwise handling gasoline

JOB HAZARD ANALYSIS		
ACTIVITY	**HAZARD**	**CONTROL**
B. Soil Sampling using floor corer	B1. Back injury	B1. Use proper lifting techniques when moving floor corer and generator
	B2. Electric shock	B2. Use electric cords free from defects, keep cords out of water
	B3. Hearing	B3. Wear hearing protection
	B4. Fire	B4. When using generator, maintain fire watch whenever refueling or otherwise handling gasoline
	B5. Radiation/ Contamination	B5. Use disposable gloves and protective clothing when collecting samples known or suspected to contain high activity levels, minimize sample contact, label sample in accordance with procedures, monitor personnel and equipment for contamination
C. Water/sediment sampling	C1. Back injury	C1. Use proper sampling and lifting techniques
	C2. Slipping/falling	C2. Use supports, tie-ups, or platforms when sampling in streams or from banks, wear personal floatation devices when sampling from a boat

JOB HAZARD ANALYSIS		
ACTIVITY	**HAZARD**	**CONTROL**
	C3.Radiation/Contamination	C3. Use disposable gloves and protective clothing when collecting samples known or suspected to contain high activity levels, minimize sample contact, label sample in accordance with procedures, monitor personnel and equipment for contamination.
D. Equipment decontamination	D1. Radiation/ Contamination	D1. Wear disposable gloves and protective clothing when decontaminating sampling equipment that has contacted materials known or suspected to contain high activity levels. Monitor personnel and equipment for contamination
	D2. Chemical	D2. When using acidic solutions or solvents, wear protective clothing, disposable gloves and eye protection. Review MSDS sheet for special precautions.

Section 9.0

Integrated Survey Procedures

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Section 9.1 – Background Measurement and Sampling

Purpose

To describe the considerations for performing measurements of background direct radiation levels and for collecting samples of media to analyze for background radionuclide concentrations

Responsibilities

- The Site Coordinator is responsible for selecting locations for background determinations and assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure while collecting background samples and measuring background radiation levels.

Locations

Outdoor

Some survey types, such as characterization or final status, will require that background samples be collected from a reference area and analyzed to provide a comparison of the status of the remediation site to natural conditions in the surrounding area. The background reference area is defined as an area that has similar physical, chemical, radiological, and biological characteristics as the site area being remediated, but which has not been contaminated by site activities. The number of samples to be collected is usually determined using MARSSIM[2] statistical guidance.

Indoor

1) Locations should be undisturbed by contamination, but may include influences determined to be naturally occurring in building materials.

2) If the background determined at the time of calibration is not representative of site conditions, or different areas on-site have influences causing backgrounds to vary, then site/area specific backgrounds should be determined. See Section 5 of this manual for procedures.

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[2] Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Section 5, Revision 1. August 2000.

Background Measurements

1) Measure the external gamma exposure rate at 1 m above the ground surface using a pressurized ionization chamber (PIC) or micro-rem meter (see Section 7.5).

2) As appropriate for the specific site, measure the alpha and beta background count rates–a minimum of ten one-minute counts–for the various construction materials encountered. These backgrounds should be performed in an area of similar construction but unaffected by radioactive material use (see Sections 7.3 through 7.4).

   NOTE: In high gamma background areas, it may be necessary to distinguish between the beta and gamma background components. This may be accomplished with a plexiglass or other suitable material beta shield that is placed over the detector. Measurements are then made with the detector in both the shielded and unshielded configuration. The beta and gamma component may then be determined based on the difference between the two measurements. Refer to Section 7.4

Background Sampling

1) Collect a sample (approximately 1 kg) of soil. Soil sampling procedures are described in Sections 8.1 and 8.2.

2) When possible, a water sample (3.8 liters) should be collected from surface sources upstream from the site of concern. Water sampling procedures are described in Section 8.4. Sediment samples if required, should also be collected at locations where surface water is obtained (see Section 8.3).

3) Collect samples of other environmental media (e.g., air and vegetation) that are appropriate based on the samples to be collected on-site.

4) Collect samples of building materials, if necessary, to determine the extent of naturally occurring radioactivity present (see Section 8.8).

Section 9.2 – General Survey Approaches and Strategies

Purpose

To describe the basic considerations for performing radiation measurements and collecting samples during surveys.

Background

Radiological surveys conducted by ORISE may be for a variety of purposes. The purpose of the survey determines the approach or strategy to be followed in developing the survey plan and, consequently, the number, location, and type of measurements and samples to be collected. This section describes the various types of surveys routinely performed and provides examples of the general survey strategies. It should be noted that the guidelines presented here represent the minimum recommendations. Additional measurements and samples are usually obtained to assure an adequate evaluation of the radiological conditions on the site in question.

Survey Types and Strategies

Scoping Survey

A scoping survey is performed to obtain information, sufficient to prepare a plan for a more in-depth survey. This type of survey usually includes only cursory judgmental scanning and measurements and limited judgmental sampling to determine the presence of radioactive contamination, identify the potential contaminants, evaluate the levels and general areas of contamination, and identify possible migration pathways. Survey locations are referenced to site-specific (grid) coordinates or other "fixed" site features.

Preliminary Survey (also Designation, Screening, or Inclusion)

To determine whether or not a site is contaminated to the extent that guideline levels are exceeded (and remedial action may be required), a designation or inclusion survey is performed. For this type of survey, measurement and sampling locations are identified in detail, relative to property lines, local coordinate systems, and/or buildings or other "fixed" site features. Survey procedures include a complete surface scan followed by direct measurements and samples. Sufficient samples and direct measurements to prove that portions of the property exceed guidelines are all that are necessary. Typically, up to 20 samples and measurements are required for this purpose.

Characterization Surveys

To delineate the extent of radiation or contamination, sufficient to evaluate potential radiological hazards and/or develop remedial action plans, a characterization survey is performed. The characterization survey includes thorough surface scans of designated and adjacent areas to identify locations of direct radiation which may indicate residual contamination. Systematic measurements and sampling are then performed throughout these areas. These measurement and sampling locations are usually at equal intervals on an established reference grid system. The number and spacing of the grid intervals must be such that sufficient data points to evaluate the radiological condition of the property are generated. Representative "hot spot" locations, identified by surface scans, are also measured and sampled to provide data on upper ranges of residual contamination levels. Data may also be used to develop radionuclide ratios and other input parameters for dose modeling or comparison to existing release criteria.

Remedial Action Support Survey

This type of survey consists primarily of multiple direct measurements and field evaluation of samples to determine the effectiveness of remedial action as it progresses. It is a field decision tool and minimum documentation of the results is necessary.

In-Process Inspection and Confirmatory/Verification Survey

The purpose of the confirmatory or verification survey is to provide independent evidence that radiological data developed by another organization is accurate and adequately represents the condition of the property. Options available for performing these surveys include standard confirmatory/verification survey or in-process inspection approaches. Each of these survey approaches also includes a review of the documents associated with the decontamination and decommissioning (D&D) activities and replication of measurements and/or analysis performed by other organizations which have developed data.

The standard confirmatory/verification survey is typically performed at the end of the decommissioning project once the site has completed their final status survey. The approach for this type of survey is to randomly or judgmentally select portions of the property and conduct thorough independent surveys. The portion of the property selected for such a survey is typically up to 10% of the total impacted area of the site to be verified or confirmed.

Larger sites may be addressed through a streamlined or in-process decommissioning inspection. This may involve several inspections of the decommissioning process (often jointly with the regulator) to evaluate specific elements of the D&D contractor's activities, usually focusing on the final status survey. An in-process inspection plan is prepared to facilitate the inspection.

These survey types rely on extensive up-front review of procedures and comparative measurements while the site's final status survey is in progress.

During a confirmatory or verification survey, representatives of the site management or their decontamination contractors may be present, and may wish to remediate areas of previously undetected contamination identified by the ORISE survey. This is acceptable as long as the pre-remediation condition of the site is documented. After remediation by site personnel, the affected areas should be resurveyed and the final condition of the site documented.

Section 10.0

Safety & Contamination Control

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Section 10.1 – Safety and Contamination Control

Purpose

To provide identification of required personnel training and monitoring, job hazard analysis, generic controls, or monitoring of common site hazards, and prevent the inadvertent spread of contamination.

Responsibilities

- Project Leaders or designated Site Coordinators are responsible for assuring that activities under their control are evaluated for potential hazards, hazard controls are developed and are performed in accordance with this manual and/or site specific safety plans, when applicable, and for reporting deviations, problems, accidents, and injuries to the program administration.
- The Survey Projects Manager or Project Leader designee is responsible for defining the work scope, developing site specific safety plans, as necessary, implementation of such plans, and coordinating efforts to resolve safety issues.
- Survey team personnel are responsible for performing all activities in accordance with hazard controls, provided both in this section and in site-specific plans, providing input on hazard controls, and bringing to the attention of the Site Coordinator any previously unidentified hazards.
- Subcontractors are to read site specific safety plans, sign acknowledgment to that effect and adhere to the plan during all site activities and bringing to the attention of the Site Coordinator any previously unidentified hazards.

Training

All program personnel must receive safety training, as mandated by the ORISE Environment, Safety & Health (ESH) office. In addition, field survey personnel will receive the following safety training:

- 40 hour Hazardous Waste Operations and Emergency Response training and 8 hour annual refresher training
- 8 hour Hazardous Waste Operations and Emergency Response Supervisors training, as applicable
- Radiation Worker II Training
- Respirator Training (as required)

- First Aid, CPR and Bloodborne Pathogen training and periodic updates as required. At least one member of a field survey team must be certified, however, ORISE attempts to maintain certification for all field survey personnel.
- Prior to each field survey, hazards specific to the site will be discussed with team members, as well as any safety requirements not covered by this manual.
- Site-specific training, as required by Project Management Contractors or other groups responsible for worker safety on site, with the approval of ORISE project management. Inquiries should be made during the project planning phase concerning site-specific training and/or testing requirements.
- Hazardous Material Transportation training.

Medical Surveillance

Physical Examination

Pre-employment physicals are performed to determine each individuals general health condition and ability to perform job requirements. Employees who are required, by the nature of job assignments, to be fitted for respirator use and/or qualified to work on hazardous waste sites, as defined by 1910.120, must have an annual physical examination.

External Dosimetry

ORISE staff members involved in field survey activities will be issued optically stimulated luminescence (OSL) dosimeters by the ESH office. OSL dosimeters are analyzed quarterly and results provided to the individual. The ESH office maintains records of all results and monitors the results to ensure that exposure levels are kept as low as reasonably achievable.

The following requirements for dosimetry use must be met:

- Dosimeters must be worn whenever an individual is working with or around sources of radiation.
- Dosimeters must not be worn during off-duty hours.
- Care should be taken to prevent accidental irradiation of a dosimeter.
- Dosimeters are to be worn on the exterior of clothing between the waist and neck.
- Personnel shall not wear dosimeters issued by ORISE while being monitored by a dosimeter issued at another site.

NOTE: You should be informed prior to arrival at a site if you are to be provided with site-specific dosimetry. If not, obtain assurance from the Radiation Safety Officer for the site that the results will be provided to you and to the ORISE ESH office. If you cannot obtain this information notify the Site Coordinator and wear your ORISE issued dosimetry. The Site Coordinator will notify the ESH office.

- Personnel dosimeters should not be packed in carry-on or checked baggage whenever traveling by air. The plastic insert from your dosimeter should be placed in your pocket prior to walking through the metal detector.
- Lost dosimeters must be reported immediately to the Project Site Coordinator.
- Pregnant employees who work in Controlled Areas are encouraged to notify their supervisor of their pregnancy. The Supervisor will notify the ESH office and a dosimeter for monthly analysis will be issued.

Whole-Body Counts and Bioassay

An emergency whole-body count will be performed if a suspected intake of gamma emitting radionuclides occurs.

An emergency bioassay will be performed if a suspected uptake of alpha or beta emitting radionuclides occurs.

Whole-Body counts and/or bioassays will be required when pre-survey hazard screening determines the need or when respirators are employed as directed by the RSO (pre and post job).

Exposure Follow-up

In the event that a potentially harmful exposure to a hazardous chemical or radioactive material occurs to any employee, supplemental examinations and/or appropriate medical testing will be initiated by the ESH office. Employees should contact a supervisor or the ESH office immediately if such an exposure is suspected.

Site Safety Assessments and Plans

Purpose

General approach for determining the safety status of survey sites and implementing appropriate requirements.

Responsibilities

Survey Projects Manager

- Ensure that an ISM pre-job hazard checklist is completed prior to all field survey activities.
- Oversee development of site-specific job hazard analyses (JHAs) and safety plans.

Project Leader or Designated Site Coordinator

- Ensure that adequate planning is performed to provide safe work environments on field sites
- Perform preliminary site visits
- Obtain site history and applicable Safety Plans already in place for a site
- Complete Site Safety Assessment Information Sheet
- Determine appropriate type of Safety Plan to be used
- Prepare site-specific JHAs, Safety Plans, or Information Sheets, as appropriate
- Provide safety information to team members during project planning stage and if site conditions change
- Ensure that tasks are performed under safe working conditions
- Resolve safety concerns in a timely manner

Survey Team Members

- Provide input/ideas concerning JHAs and safety aspects of field surveys
- Discuss safety concerns with the Site Coordinator
- Follow requirements of the Safety Plan
- Report all unsafe conditions to the Site Coordinator

Approach

Pre-survey

- Site Coordinator obtains the site history and any safety plans that may have been put in place by the owners or designated project management contractor.

- Based on cost and time constraints, a preliminary site visit may be performed. The visit will include a visual inspection of the site, video taping whenever possible, and interviews with appropriate site representatives to determine site conditions. Requirements for site entry, such as documentation of training or medical surveillance, will also be determined. When a preliminary site visit will not be conducted pertinent information will be requested from site contacts or agency representatives.
- An **ISM pre-job hazard checklist** is completed, including basic site information and suspected hazards.
- The Survey Projects Manager reviews the ISM pre-job hazard checklist and may request ESH office assistance to determine the applicability of this manual as the generic plan, use of a project management contractor plan, or the necessity of a site-specific JHA or safety plan. Site specific JHAs will be prepared when unique hazards are identified. Based on these recommendations the Survey Projects Manager determines the approach to be used.
- When a site-specific plan is necessary, an ISM plan for new or modified work is prepared for review by the Survey Projects Manager. The plan is also submitted to the ESH Director/designee for review.
- Site conditions and safety requirements are discussed with the survey team during the pre-survey meeting. Questions and concerns will be discussed and resolved prior to the start of survey activities.
- Requirements for special safety equipment, training, monitoring, and identification of hazardous working conditions that affect subcontracted groups will be defined in related procurement documents. Required documentation of subcontractor training must be obtained prior to the start of work.
- Safety requirements for equipment/supplies to be purchased or rented will be defined in related purchase requisitions.
- Long-term projects have the initial safety evaluation performed that is discussed above. Additionally, all staff are required to continually evaluate the work site for changing conditions that may result in new or previously unidentified hazards and report any new hazards to the cognizant site supervisor and Survey Projects manager. Work will be suspended pending the completion of a job hazard analysis and implementation of any necessary controls.

On-Site

- An on-site meeting for ORISE subcontracted personnel will be held by the Site Coordinator to ensure that all individuals understand requirements and documentation to that effect is obtained.
- Changes to initially identified safety requirements by site or agency representatives for equipment, procedures, or worker training should be reported to the Survey Projects Manager at the first opportunity, and documented in the site logbook.
- All survey team members are required to report unsafe conditions to the Site Coordinator immediately. All safety concerns will be addressed and resolved prior to start of work in the area/situation in question. Documentation of the resolution of concerns is required. Any injuries are to be reported immediately to the Project Leader or Survey Projects Manager and ORISE reporting and follow-up procedures implemented.
- The Site Coordinator should contact the Survey Projects Manager for guidance in unexpected situations where completion of survey plan requirements would require re-evaluation of safety conditions or significantly more time than expected. As necessary, new JHAs may be prepared when unexpected safety concerns are identified on site.

Post-Survey

- Pertinent information concerning safety, such as incidents of personnel injury or contamination, will be identified in the trip report and other records completed as required by ESH procedure. For surveys performed in multiple phases, identify the presence of significant changes to site conditions requiring re-assessment of the present safety plan.
- Lessons learned (including operational experience) are to be shared with the ORISE and ESH Lessons Learned Coordinators and other staff members as appropriate.

Safety Plans

Generic Plans

- For most work sites, special hazards have been removed as part of the remedial action activities; associated safety hazards are typically limited to those common to industrial and construction sites. Requirements for safe work at such sites are presented in this manual. Some typical hazards encountered on survey sites are:
    - Trenches and excavations

- Working at heights; ladders, scaffolds, man lifts
- Trip hazards
- Working with or around motorized equipment
- Temperature extremes
- Biological hazards, such as poisonous plants, snakes, insects
- Electrical hazards

Site-Specific Plans

Site-specific plans will be developed when the guidance provided in this manual is not sufficient to provide direction to ensure acceptably safe working conditions or where specific information/direction is needed to have a safe working environment. Some examples of such situations are:

- Special personnel monitoring requirements
- Requirement for respirator use
- Protective clothing requirements for contamination control
- Special decontamination requirements for personnel or equipment
- Identified potential for the generation of radioactive or hazardous waste
- Confined space entry

The plan will include the following information, at a minimum.

- Site history and description
- Objectives and scope of work
- Project safety responsibilities
- Hazard analysis
- Site access controls
- Engineering controls
- Exposure monitoring plan
- Personal protective equipment
- Procedures for safe conduct of special tasks
- Decontamination methods
- Communication methods
- Personnel training

- Medical surveillance
- Stop work indicators
- Emergency response plan

Copies of these plans will be provided to ORISE survey staff and/or ORISE sub-contractors working on the site. One copy will be available on site at all times.

Working Under the Plans of Others

In situations where a site management contractor or other group is responsible for safety on a site, it may be requested that ORISE employees meet the requirements of that group's safety plan. The plan in question will be reviewed by ORISE project management and ESH to determine the completeness and applicability of the information provided. ORISE requirements for safety must always be met. More stringent requirements may be adopted, as necessary.

Communications

Conditions on typical survey sites allow for normal voice and/or hand signal communications. Cellular phones may also be used.

Program personnel, to the degree possible, should work in teams of at least two people. Personnel may work individually if they are within visual or voice range of either coworkers or other cognizant project subcontractors or regulators. Use of short-range radios may also be used as a means to permit staff to work individually, provided there are no unusual hazards either within the work area or with the task being performed.

Site Controls

When entry controls have been established at a site by other responsible groups, appropriate procedures will be referenced or provided in the specific safety plan. In cases where the need for such controls is identified by ORISE personnel based on findings as a survey progresses, the Site Coordinator will be responsible for determining the type and duration of use.

Area Monitoring

General

Results of area monitoring pertaining to ORISE work activities that are performed by non-ORISE personnel should be obtained, reviewed and placed in the project file. In the event that a review identifies significant concerns about working conditions, the ESH office must be informed.

Assessment of Exposure Level

With very few exceptions, ORISE activities deal with radiation levels and radioactive material concentrations near typical background values; it is very unlikely that measurable radiation exposures will occur. Special precautions will be taken in cases where the possibility of significant personnel exposure exists.

When unanticipated situations arise which cause exposure rates to exceed the detection capability of a NaI(Tl) detector, personnel must leave the area and contact the Site Coordinator.

If conditions in the field arise that change the scope of the operation or impact the hazard control established for the site work, the Site Coordinator will notify the ORISE RSO.

Removable Contamination Assessment

Review of available site history will usually be sufficient to identify the potential for removable contamination. Routine survey activities provide the means for continuous monitoring by way of smear sampling and direct surface scans and measurements.

Air Quality Assessment

Prior to entering areas having questionable air quality, monitoring must be done or results of monitoring by others must be reviewed, to assure safe working conditions.

Assessment of areas having excessive airborne particulate can be performed in conjunction with the ESH office.

NOTE: Operating procedures for calibration and use of the combustible gas indicator/oxygen meter and the organic vapor meter are listed I n Sections 10.2 and 10.3 respectively. Air quality monitors other than those described below may be rented and used at survey sites. The calibration procedures of the manufacturer will be followed in these cases and noted in the site logbook.

Personal Protective Equipment

Personal protective equipment (PPE) is provided whenever conditions are present that could cause bodily injury or impairment of the body through absorption, inhalation or physical contact of/with hazardous substances. These conditions may be present due to hazards produced by the environment, chemical, or radiological materials or mechanical irritants.

PPE is used in accordance with 29 CFR 1910.120 and 132, and the *ORISE Health and Safety Manual* and the *ORISE Radiation Protection Manual*. The ESH office will assist ORISE survey program managers in all issues related to selection, use, training and limitations of PPE. In all situations where possible, engineering controls will be used to reduce or eliminate hazards. Respirators are used in accordance with ANSI Standard Z88.2 and OSHA 1910.34.

Responsibilities

- **Supervisors** - Assure that appropriate protective equipment is provided and used correctly.
- **Employees** -
  - ✓ Follow established guidelines
  - ✓ Notify supervisor about incorrect use of PPE
  - ✓ Notify supervisor about faulty or worn out PPE

Selection of PPE

PPE requirements will be determined on a site-specific basis and, if determined to be applicable, will address the following:

- Site hazards
- Conditions for use
- Limitations of use
- Task duration
- Maintenance and storage
- Decontamination and disposal
- Training and fitting
- Donning and doffing procedures
- Equipment inspection procedures
- On-going evaluation of PPE effectiveness

Radiation and Contamination Control

With very few exceptions, Program activities deal with radiation levels and radioactive material concentrations near typical background values; it is very unlikely that measurable radiation exposures will occur. Special precautions will be taken in cases where the possibility of significant personnel exposure exists. Of greater concern in survey activities is the potential contamination of field and laboratory equipment and cross contamination of analytical samples. Should site conditions warrant, ESH will prepare a radiological work permit (RWP). The ORISE RSO has provided additional clarification to the *ORISE Radiation Protection Manual* requirements for when an RWP is to be prepared. Personnel may work in areas with fixed activity levels in excess of the RPP

Appendix B values provided removable activity levels are less than the Appendix B values and dose rates do not exceed 5 mrem/h in any one hour.

Personnel

In potentially contaminated areas all personnel shall wear appropriate personal protective clothing and refrain from eating, drinking, smoking, or other activities that could lead to intake of material. Radiation dosimeters are to be worn during all assignments having a potential for exposure to personnel.

ORISE will provide appropriate personnel radiation monitoring services and contamination control clothing for use by subcontractor personnel. Details regarding selections and assignment of monitoring devices and control equipment will be provided by the ESH office. Upon exiting potentially contaminated areas, thorough monitoring of clothing and skin surfaces is required. If contamination is identified, the Site Coordinator will determine the appropriate action to be taken. Instances of personal contamination and steps taken to remove the contaminant shall be recorded in the site logbook and the ORISE RSO will be notified.

Gamma scanning will be performed as part of the survey activities and will detect any levels of radioactivity not previously identified that could pose a significant radiological external exposure to site personnel. Should situations arise which cause exposure rates to exceed the detection capability of the NaI(Tl) detector, personnel should leave the area and contact the Site Coordinator. When dealing with radiological contamination, consideration should also be given to the control of related biological, chemical, and physical hazards.

Radioactive Source Control

Sealed or electroplated sources used for operational check-out of portable survey instruments are tracked using a computer inventory program. Sources must be logged out prior to removal from the Oak Ridge facility and logged in upon return to inventory. In the event sources are loaned to another organization, they will be tracked by means of chain-of-custody. Calibration sources must not be removed from the Oak Ridge facility without the approval of the ORISE Environmental Laboratory Manager.

ORAU operates under a DOE a contract, and is license exempt by Section 30113, Part 30, by-product material, Title 10, CFR.

Equipment and Vehicle Surveys

All equipment and vehicles used in potentially contaminated areas are to be scanned, and cleaned if necessary, prior to leaving the site to assure that contamination is not inadvertently moved out of controlled areas. The results of these scans must be documented in the site logbook.

When there is a potential for contamination of containers or vehicles during sample transport, suspect surfaces will be surveyed. Should decontamination be necessary, a follow-up survey will be performed to assure that all surface activities are maintained as low as reasonably achievable. The results of vehicle surveys must be documented in the logbook. Documentation that no potential for contamination was encountered can be done by noting the situation in the logbook. Surveys of equipment or other items must also be documented in the site logbook.

Decontamination

Equipment used for sample collection should be surveyed, and cleaned as necessary, following each use.

List of Equipment

- ✓ tap water
- ✓ deionized water
- ✓ non-phosphate detergent
- ✓ alcohol (isopropanol)
- ✓ spray bottles
- ✓ stiff bristle brush
- ✓ paper towels

Procedure

1) Wipe equipment surfaces free of loose material using paper towels or brushes.
2) Rinse with tap water.
3) Wash with detergent solution and brush.
4) Rinse with tap water.
5) Rinse with deionized water.
6) Rinse thoroughly with isopropyl alcohol.
7) Allow to air dry.

NOTE: Monitoring routinely performed at the sampling location will provide an indication as to the need for special attention following sampling. Any necessary decontamination should be performed such that potentially contaminated waste, generated in the process, can be collected and assessed to determine the appropriate disposal method. All samples known or suspected of containing levels of radioactivity which could present a contamination or exposure problem in the field or laboratory are to be placed in clean outer containers and identified with a radiation warning label or other explanatory information, as appropriate.

Personnel

The risk of personnel contamination is very low on most ORISE survey sites; however should it occur, soap and water should be used to remove any contaminated material, and the area monitored with appropriate instrumentation to assure the material has been completely removed. Documentation of all instances of personnel decontamination activities must be documented in the site logbook and the ORISE RSO notified.

Portable showers and eyewash stations should be set up for ready access during work activities having a potential for eye contamination or significant skin contamination.

Vehicles

Vehicle exteriors will be surveyed and decontamination performed, if necessary, prior to removal from areas of the site suspected of having accessible removable contamination. See the requirements in the "Radioactive/Hazardous Waste Handling and Disposal" section of this procedure.

It may occasionally be necessary for survey staff to transport materials which require special packaging and labeling. Examples of such materials are radioactive materials, chemical reagents, and P-10 compressed gases. The Site Coordinator, or their designee, is responsible for working with the Laboratory Manager and the ORISE Facilities and Transportation Department (FTD) to assure that the appropriate paperwork is completed according to Department of Transportation regulations and that the appropriate containers and restraining devices are used. If FTD determines that vehicle placarding is necessary for a specific material, survey staff can not transport because a commercial drivers license is required to operate a vehicle requiring placarding.

Procedures for hazardous material transport

The Laboratory Manager, or designee will call the ORISE TSS and provide the following information:

- Destination name
- Destination address
- Name of contact person at destination
- Material type
- Quantity and size of containers

The TSS office will send the Laboratory Manager or designee the following:

- Material Safety Data Sheets
- D.O.T. regulation
- Shipping papers for transport (one way or round trip, as applicable)

The driver transporting the material must sign the shipping papers before leaving the facility. The completed paperwork must be carried in the cab of the vehicle at all times that hazardous materials are being transported. When the driver is in the vehicle, the documents must be carried in the driver's side door pocket or on the seat to the right of the driver. When the driver is not in the vehicle they must be in the driver's side door or on the driver's seat.

When it is necessary to transport the material (or any remaining portions) back to the facility, the return trip shipping papers must be signed by the driver prior to departure.

Upon arrival at the facility, the driver should file the signed shipping papers for return to the ORISE FTD.

NOTE: If you are unsure of the classification of a material, contact the FTD shipping representative.

Radioactive/Hazardous Waste Handling and Disposal

Routine field survey activities do not generate radioactive or hazardous waste material. In situations where the potential for such material to be generated has been identified, handling and disposal procedures will be included in the site-specific safety plan.

Standard Safe Work Practices

The following safe work practices should be followed at all times.

- All work will be conducted in accordance with applicable regulations, ORISE procedure manuals and site survey plan.
- Potential hazards identified during survey activities will be communicated to all site personnel immediately. Survey personnel must then perform a job hazard analysis, develop and implement hazard controls, and work within established controls. New situations encountered, that had not been previously addressed, must be documented in the site log book.
- Team members will work in pairs or have assistance available by other workers present in the vicinity.
- A first aid kit will be available on site.

- Work areas will be kept as clean as possible and will be kept orderly and free of obstacles.
- Open excavations, trenches, etc. will be clearly marked and protected.
- Underground utilities will be identified prior to beginning any subsurface activities.
- Caution will be used and generous clearance given when overhead wires or other electrical hazards are present.
- Non-sparking tools, ventilation, purging, and other precautionary measures will be taken when working with or in the vicinity of flammables.
- Area or task specific personal protective equipment will be worn and maintained properly.
- Eating, drinking, or smoking will be limited to designated locations only after the locations have been determined to be free of contamination and any other adverse conditions (poison ivy, flammables, etc.). These activities are allowed only after appropriate personnel decontamination procedures have been followed.
- Emergency equipment will be readily available and contaminant free.
- Work activities will be planned so that contact with potentially contaminated surfaces and/or materials is kept to a minimum.
- Field personnel will monitor themselves, and one another, for signs of physical stress and communicate any adverse effects that are noticed to the Site Coordinator.
- Air monitoring will be conducted as appropriate.
- Injuries, no matter how minor, will be reported to the Site Coordinator. Accident report forms will be prepared when applicable.
- Appropriate personnel and equipment decontamination procedures will be instituted to prevent the migration of contaminants.
- A copy of the Survey Procedures Manual and, if applicable, Site-Specific Safety Plan will be kept available on site at all times.

Excessive Noise

Survey sites will be assessed for the presence of excessive noise conditions. Identification of the potential for an 8 hour time weighted average of 85 dBA during survey activities will necessitate further monitoring and/or the use of hearing protection. The ESH office will be contacted for assistance in determining appropriate protection devices.

Heat Stress

Excessively hot and humid working conditions can cause stress and discomfort which may diminish work performance. Individual physiological characteristics such as age, body composition and size, fitness level, and level of acclimation will influence susceptibility to heat stress.

Responsibilities

Site Coordinator

Assess working conditions on site for heat stress potential. Monitor workers as necessary. Institute adequate work breaks for the conditions. Ensure availability of potable water.

Team Members

Use all required protective clothing and equipment. Be aware of heat stress symptoms and assess self and co-workers conditions. Drink water frequently. Work at a pace appropriate for the work conditions.

Work Task Assessment

- Planned work activities will be assessed for associated heat stress potential, and will be identified in the Site Safety Assessment. The ESH office is available to assist with work activity evaluations.
- Required PPE, equipment or procedures will be specified in the Site-Specific Safety Plan or the Site Hazard Information Sheet.
- Work conditions and requirements will be discussed with the team in the pre-survey meeting.

Precautions and Monitoring

Some options for personal protection are: circulating air systems, ice cooling garments and reflective clothing.

General work practices for potential heat stress situations are:

- Self evaluation
- Frequent fluid replacement
- Acclimation
- Buddy system

- Scheduling of such activities during the coolest possible times
- Determination and use of "stay" and "recovery" times.

Confined Space Entry

A confined space is an enclosed area having all of the following characteristics:

- It is not designed for human occupancy
- It has restricted entry and exit
- It contains potential or known hazards

  NOTE: Examples are storage tanks, boilers, ventilation or exhaust ducts, sewers, and manholes. Open top spaces more than four feet deep may also be confined spaces if the above characteristics apply. Confined spaces have been implicated in serious bodily harm and death. Extreme caution should be exercised in encountering any conditions having the appearance of a confined space.

When the need for confined space entry on a survey site has been identified during the project planning stages, a written entry plan will be developed in accordance with 29 CFR 1910.146. Entry may be performed under the requirements of another organization, designated by the applicable funding agency as responsible for safety for a site, i.e. a Project Management Contractor. In such cases, the safety plan will be reviewed, and approved by the ORISE Survey Projects Manager prior to the start of on-site activities.

A permit-required confined space is a confined space that has one or more of the following characteristics:

- Contains or has the potential to contain a hazardous atmosphere;
- Contains a material that has the potential for engulfing an entrant;
- Has an internal configuration such that the entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section;
- Contains any other serious safety hazard.

When the need for permit-required confined space entry has been identified an entry permit system must be in place. In situations where such a system has been established by site owners or by a management contractor the ORISE Survey Projects Manager may choose to utilize that system. The written procedure must be obtained, reviewed, and approved by the Survey Projects Manager, and consent from the responsible group must be obtained prior to beginning work activities in the space. In situations where ORISE will be required to establish a permit entry system, the ESH office should be contacted for assistance.

Heavy Equipment Operation

Heavy equipment such as drilling rigs and man lifts will, in most cases be operated by personnel from contracted organizations or representatives from the survey site. ORISE survey staff will not operate such equipment unless prior arrangements have been made to ensure that appropriate training and protective equipment concerns have been addressed by the Site Coordinator. The following general rules will apply in all cases:

- The operator will use all safety devices provided with the equipment.
- Personnel not required in the area must keep a safe distance from the equipment during operation.
- Personnel who must work in proximity of operating equipment will be responsible for avoiding the equipment's path and areas that may be blinded from the operator's vision.
- Occupancy limits will be observed at all times.
- Good housekeeping will be practiced at all times in equipment operation areas.

Asbestos

Site Assessments

Survey sites will be assessed for the presence of asbestos. A visual investigation will be performed during the preliminary site visit, if possible. Information will also be requested from site and/or agency representatives. If asbestos is determined to be present, the locations and characteristics will be determined. If monitoring results are available the results will be evaluated. Concentration of fibers present in the air that is greater than 0.02 fibers/cc requires that respiratory protection be used in the area. OSHA recommends an action level of 0.01 fibers/cc to determine whether any personal protective equipment is required. The ESH office personnel are available to conduct area monitoring on sites where a potential exists but data are not available.

Countermeasures

Every effort should be made to provide an asbestos-free working atmosphere. The Survey Projects Manager will attempt to schedule survey activities after asbestos remediation is complete or the asbestos has been contained. Activities that must take place when greater than 0.02 fibers/cc are present will require that respiratory protection and the appropriate PPE be used.

Work at Heights

Ladders

- Should be inclined so that the horizontal distance from the top support to the foot of the ladder is one-quarter of the ladder length.
- Should be placed to prevent slipping, or it must be lashed or otherwise held in position.
- Ladders used for access to a roof should extend at least 3 feet above the point of support.
- Position the ladder to prevent overreaching.

Scaffolds

- Footing and anchorage must be sound, rigid and capable of supporting the maximum intended load without displacement.
- Scaffolds and their components must be capable of supporting at least four times the maximum intended load.
- Arrangement of planking for platforms must leave no spaces and must not overlap. Planks must extend between 6 and 18 inches past their end supports.
- Scaffolds may not be altered or moved horizontally while they are in use.
- An access ladder or equivalent safe access shall be provided.
- When overhead hazards exist protection must be provided.
- Where persons are required to work or pass under the scaffold, a screen must be provided between the toe board and the guardrail over the entire opening.
- Employees shall not work outside on scaffold during storms or high winds, or with snow or ice present on scaffold.
- For scaffolds more than 10 feet above the ground, guardrails at least 2 H 4 inches in size and between 36 and 42 inches high, and toe boards must be installed at all open sides.

Man lifts

- Only trained persons may operate aerial lifts.
- Employees will stand firmly on the floor of the basket, and shall not sit or climb on the basket edge.

- A body harness must be worn with the lanyard attached to the boom or basket.
- Boom and basket load limits specified by the manufacturer will not be exceeded.
- Breaks must be set and outriggers, when used, must be positioned on a solid surface.
- Only specifically designed aerial lift vehicles may be moved when the boom is elevated with workers in the basket.
- Articulating and extendible boom platforms must have both platform and lower controls. Lower level controls must provide for overriding platform controls, however, they must not be operated unless permission has been obtained from the employee in the lift, except in emergencies.

Electrical Hazards

- Consider all electrical circuits to be dangerous. Do not assume that a line is "dead." Treat all lines as though voltage is connected.
- Respect all lock-out tag-out situations.
- All extension cords must be the three-wire type and Underwriter Laboratory (UL) approved; worn or frayed cords will not be used. Cords must be kept clear of working spaces, walkways, and water.
- Temporary lights should be equipped with guards to prevent accidental contact with bulb unless bulb is deeply recessed.

Compressed Gas Cylinders

- Cylinders will be stored secured to a wall or post or placed in specifically designed crates when not attached to survey carts.
- Caps will be kept in place when cylinders are not in use.
- Do not lift cylinders by the valve or cap.

Excavation Entry

- A safe means of egress must be located in trench excavations that are 4 feet or more in depth so as to require no more that 25 feet of lateral travel.
- No employee will be permitted underneath loads handled by lifting or digging equipment.
- For excavations greater than 4 feet in depth where oxygen deficiency, less than 19.5% oxygen, or a hazardous atmosphere exists or could reasonably

be expected to exist, the atmosphere in the excavation must be tested prior to entry.

- Adequate precautions must be taken to prevent employee exposure to atmospheres containing less than 19.5% oxygen and/or a concentration of a flammable gas in excess of 10% of the LEL of the gas.
- When atmospheric controls are in place, testing must be performed as often as necessary to ensure that the atmosphere remains safe; emergency rescue equipment must also be available and manned.
- Employees will not work in excavations in which there is accumulated water, or in which water is accumulating, unless adequate precautions have been taken to protect employees, such as support or shield systems to protect from cave-in, water removal to control the level of accumulating water, or use of safety harness and lifeline.
- Adjacent structures must be stabilized.
- Adequate protection from loose rock, soil, or other materials that could fall or roll from the excavation face is required.
- Daily inspections must be conducted prior to the start of work and as needed thereafter.
- Employees must be protected from cave-ins except when the excavation is made entirely of rock or it is less than 5 feet deep and an examination provides no indication of potential cave-in.

Vehicle Operation

The following requirements are in place for the operation of any ORISE DOE vehicle or rented vehicle.

- Use for official business only.
- Practice defensive driving and adjust driving practices to road and weather conditions.
- Report all accidents to your supervisor immediately. Supervisor must report accidents to the Site Safety Representative as soon as practical. Appropriate forms and instructions are provided in all DOE vehicles. In the event of an accident, these forms must be completed and sent to the ESH office within seven days, with copies to ORISE survey management.
- Vehicles used for out of town travel are to be inspected before leaving Oak Ridge, before leaving to return to Oak Ridge, and after returning to Oak Ridge. Always verify that the accident/insurance

paperwork is in the glove compartment. Key items to inspect are the following:

- ♦ Tires (pressure) and wheels (lugs);
- ♦ Head lights, tail lights, brake lights, backup lights, and turn signals;
- ♦ Instrument panel for fluid levels (including fuel), warning lights, and buzzers;

- Vehicles used under conditions which pose a contamination potential will be monitored and results documented.
- Transport of hazardous materials must meet the requirements outlined in the "Procedures for Hazardous Material Transport" section of this procedure.

Emergency Response

General Guidelines for Injuries/Illnesses

- Non-critical emergencies–render first aid.
- Serious incidents–render first aid and transport to medical facility.
- Critical incidents–call 911 and request ambulance.
- Report incident to supervisor as soon as practical.

Emergency Assistance

Emergency services are rarely available on survey sites however, 911 service (police, fire, ambulance) is usually available for the area. A mobile phone should be available on site whenever another phone line is not available.

Survey teams should have at least one individual who holds current certification for first aid, cardiopulmonary resuscitation, and bloodborne pathogen training. As general practice, ORISE prefers that all field personnel hold current certifications.

The most direct route to the nearest medical facility will be identified by the Site Coordinator prior to start of work on the site and the information provided to the survey team.

All injuries should receive prompt medical attention; first aid and/or professional medical treatment. Personnel are encouraged to call the local rescue squad and/or ambulance and hospital services when, in their judgment, such services are required. The following forms must be completed and submitted to the ESH office within seven days of the event (see Figures 10-5, 10-6, and 10-7):

- Employee's First Report of Work Injury
- Supervisor's Investigation Report
- Authorization to Release Medical Information

If medical attention is required, apprise the attending physician that the injury will be covered under ORISE's Worker's Compensation Program (Policy ESH-1100). If the provider should refuse treatment on this basis, notify the ESH office immediately at (865) 576-3333 or call the ESH office Hotline number at (865) 310-5555.

Vehicle Accidents

- In the event of an accident involving a DOE vehicle, call for police assistance, follow instructions, and complete the forms provided in the vehicle.
- In the event of an accident involving a rented vehicle, call for police assistance. Obtain copies of all reports including pertinent information about other individuals who may have been involved.

Fire

In the event of a fire:

- Evacuate the area
- Account for all personnel
- Call 911, or other available emergency number as soon as it is safe to do so.

Section 10.2 – Combustible Gas Indicator/ Oxygen Meter Calibration and Use

Purpose

To describe the procedure for calibration and use of combustible gas indicator/oxygen meter (CGI/O2).

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ MS Microgard; or equivalent equipment.
- ✓ Calibration gas (0.75% pentane/15% oxygen in nitrogen air mixture), as applicable.

Calibration Procedure

1) Press the ON/OFF key pad. Verify that the display functions appear.
2) Perform a battery check by pressing the "Batt Volts" key pad. The acceptable range is 2.20 to 2.90 volts. When the battery pack voltage is no longer sufficient to profile accurate readings (approximately 2.10 volts), the audible alarm latches on and sounds continuously (non-pulsing).
3) Press the "RESET" key pad after 10 seconds to allow the meter to stabilize. The combustible gas alarm will sound and "% LEL" will be displayed. The pump motor turns on and the flow indicator verifies air flow with a bouncing bead. Press "RESET" again to silence the alarm and obtain a display of 000% LEL.

NOTE: If the "000% LEL" display is not obtained adjust the zero control (Z:LEL) located under the side coverplate.

4) <u>Oxygen Calibration</u> – In fresh air, press "SELECT" key until the display indicates "% OXY" and release. Allow sufficient time for stabilization. The accepted value is 20.8% OXY. If needed, adjust the span control (OXY:S) in fresh air until the display indicates 20.8.

5) Combustible Gas Calibration – Instrument must be calibrated for oxygen in a fresh air environment prior to this calibration. Press "SELECT" key pad until "% LEL" mode is displayed.

   Connect regulator and hose to calibration gas bottle, open valve to begin flow, and connect hose to the meter. Allow the gas to pass through the instrument.

   The acceptable reading should stabilize at 47-55%. If the reading is not in this range adjust the S:LEL control (located under the side coverplate) to 50%. The factory set alarm level is set at 25% LEL. Change the setting to 19% LEL.

   Disconnect hose from the instrument, turn off gas, and remove regulator.

Measurement Procedure

1) The combustible gas indicator should be used whenever there is a concern for the oxygen content of the air or a potential for the presence of combustible gas.

2) To use, turn the instrument on. An extension tube may be used to remotely monitor, such as in a confined space. Typically, the air is monitored in both the breathing zone (1.5 to 2 meters high) as well as at ground level where heavier-than-air gases or fumes may accumulate.

3) If the alarm should sound, a light indicator will show which situation, either oxygen or combustible gas, has occurred. Corrective action must be taken and no entry allowed to an area in which levels are the following:

   Less than or equal to 19.5% OXY indicates low oxygen content

   Greater than or equal to 21.5% OXY indicates enriched oxygen content

   Greater than 10% LEL indicates action required for combustible gas

   25% LEL sounds alarm for combustible gas

   NOTE: LEL interference could occur in low oxygen environments.

Section 10.3 – Organic Vapor Meter Calibration and Use

Purpose

To describe the procedure for calibration and use of organic vapor meters.

Responsibilities

- The Site Coordinator is responsible for assuring that this procedure is implemented.
- Survey team personnel are responsible for following this procedure

List of Equipment

- ✓ Organic Vapor Meter, Thermo Environmental Instruments, Inc., Model 580B, or equivalent
- ✓ Zero Air Tank
- ✓ Span Gas (isobutylene, 250 ppm, or other)

Calibration Procedure

1) Install the appropriate energy lamp (10eV or 10.6 eV dependent upon potential contaminants) into unit according to instrument manual.
2) Attach power plug (on attached chain) into RUN/CHG port and turn on.
3) <u>Zero Air Calibration</u> – calibration mode may be entered by pressing "RESET". The window display will be:
   "RESTORE BACKUP, + = YES".

   Press "-/CRSR" to continue calibration mode. The display will show: "ZERO GAS – RESET WHEN READY".

   Connect regulator and hose to the zero air bottle, open valve to begin flow, and connect hose to the meter. Allow air to flow through the meter.

   Press "RESET" to calibrate. When the 580B has been zeroed the display will show: "SPAN PPM 0000".

   Disconnect hose from instrument, turn off gas, and remove regulator.

4) Span Gas Calibration – Set the span gas concentration (labeled on gas bottle) by simultaneously pressing "RESET" and either "+/INC" to increment the digit above the cursor or "-/CRSR" to move the cursor.

   When the correct concentration has been entered, press "+/INC" (without the "RESET", as above).

   Connect regulator and hose to span gas bottle, open valve to begin flow, and connect hose to the meter. Allow the gas to flow through the meter.

   Press "RESET" to calibrate. When the 580B has been calibrated the display will show: "RESET TO CALIBRATE".

Measurement Procedure

1) The organic vapor meter should be used whenever there is a potential for the presence of organic vapors.
2) To operate, enter operating mode by pressing "MODE/STORE". Air monitoring is then performed either on a continuous basis or at prescribed intervals in the breathing zone and at ground level, borehole, etc.
3) The alarm may be set at a threshold which corresponds to the permissible exposure limit (PEL) of known contaminants at a site. If potential contaminants are unknown, select an alarm level of 2 ppm.