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Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program

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PROCEDURES MANUAL FOR THE ORNL RADIOLOGICAL SURVEY ACTIVITIES (RASA) PROGRAM

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PROCEDURES MANUAL FOR THE ORNL
RADIOLOGICAL SURVEY ACTIVITIES (RASA) PROGRAM

ASSIGNED TO_____

Each person to whom a manual is assigned shall maintain it in proper order, inserting new or revised pages upon their receipt. When the assignee transfers or terminates, or when the manual is no longer needed, the manual should be returned to the ORNL/RASA office.

Immediately upon receipt, the assignee is required to tear off this section of this sheet, sign, and return to B. A. Berven, RASA Program Manager, Oak Ridge National Laboratory, P. O. Box X, Building 7503, MS-382, Oak Ridge, Tennessee 37831.

I acknowledge receipt of the Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program.

NAME_____

DATE:_____

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1. INTRODUCTION

1. INTRODUCTION

1.1 INTRODUCTION

Since 1972, numerous federal agencies have been involved in programs to determine the radiological condition of sites used in the early days of the atomic energy program in the United States. The sites of concern were federally, privately, and institutionally owned and were used primarily for research, processing uranium and thorium ores, and storage of radioactive ores or residues.

As part of this federal effort, the Department of Energy's (DOE) office of the Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness has been assigned the responsibility for identifying, characterizing, recommending remedial action as appropriate, and, ultimately, certifying the radiological conditions at each of the designated sites. In response to this mandate, the Radiological Survey Activities Program (RASA) has been established within the Office of Operational Safety (OOS) at the Oak Ridge Operations office of DOE. The scope of activities in the RASA Program includes:

- Sites formerly utilized under contract with the Manhattan Engineer District and the U.S. Atomic Energy Commission (MED/AEC) and covered under DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP),
- Inactive uranium mill sites covered under DOE's Uranium Mill Tailings Remedial Action Program, and
- Surplus DOE contractor facilities owned by the U.S. Government.

Performance of the survey efforts included in the RASA program has been delegated to several institutions, including Oak Ridge National Laboratory (ORNL) operated by Martin Marietta Energy Systems, Inc., Oak Ridge Associated Universities (ORAU); Argonne National Laboratory (ANL); and the Mound Facility (Monsanto).

The portion of the survey program performed by ORNL is the subject of this Procedures Manual. The RASA group of the Health and Safety Research Division (HASRD) at ORNL is responsible for the planning, conducting, and reporting of the results of radiological surveys at specified sites and associated vicinity properties. The results of these surveys are used by DOE in determining the need for and extent of remedial actions. Upon completion of the necessary remedial actions, the ORNL-RASA group or other OOS contractor may be called upon to verify the effectiveness of the remedial action. Information from these postremedial action surveys is included as part of the data base used by DOE in certifying a site for unrestricted use.

1.2 PURPOSE

The purpose of this Procedures Manual is to provide a standardized set of procedures that document in an auditable manner the activities performed by the ORNL-RASA group for DOE's RASA program. The Procedures Manual insures that the organizational, administrative, and technical activities of the ORNL-RASA group conform properly to the requirements of the RASA program and that the procedures and techniques used by the ORNL-RASA group and contractor personnel meet the requirements of applicable governmental, scientific, and industrial standards.

1.3 SCOPE

This Procedures Manual is sufficiently comprehensive for use by ORNL-RASA and other RASA contractor personnel in the planning, performance, and reporting of radiological surveys. The manual provides formal procedures for conducting radiological surveys at remote sites and includes program planning, equipment operation, and quality assurance elements. The instrumentation and analysis methods on which these procedures are based are specific to the ORNL-RASA program. However, the survey planning and report preparation procedures are applicable to all RASA participants. The manual, as it is described in Sect. 1.6, Utilization of Manual, consists of:

1. Introduction (Sects. 1.1 through 1.6)
2. Integrated Activity Functional Description (Sects. 2.1 through 2.3)
3. Planning Procedures (Sects. 3 through 9)
4. Implementing Procedures (Sects. 10 through 21)

Sections 1 and 2 provide organizational and general descriptive information about the RASA program and its functions, as well as a description of the use of the manual. Sections 3 and 4 contain the procedures for planning and implementing the radiological surveys and evaluations in support of the RASA program.

1.4 QUALITY ASSURANCE POLICY STATEMENT

For projects involving activities such as those in the RASA program, it is the policy of Martin Marietta Energy Systems, Inc. (operator of ORNL under contract with the U.S. Government) to perform technical services in accordance with accepted quality assurance (QA) practices.

The ORNL-RASA program manager is responsible for establishing QA policies, goals, and objectives for ensuring that the program developed is adequate and properly implemented.

The planning and implementing procedures contained in this manual provide QA for documents, activities, materials, and equipment, and also provide for surveillance of the activities related to QA. Individuals using this Procedures Manual should be familiar with its QA provisions and consider that participation in the RASA program is governed by those provisions.

1.5 TERMINOLOGY

The general information in Sects. 1.5.1 (Definitions), 1.5.2 (Abbreviations), and 1.5.3 (Acronyms) is provided to clarify the use of various terms and symbols used in this manual. Where important to the understanding and use of particular procedures, some definitions are repeated in the sections describing specific procedures. Additional definitions, abbreviations, and acronyms pertinent to specific procedures are also provided as part of the description of these procedures, as necessary.

1.5.1 Definitions

ABSORBED DOSE. The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the point of interest. The unit of absorbed dose is the rad. (The international system [SI] unit is the Gray.)

AERIAL SURVEY. A search for sources of radiation by means of sensitive instruments mounted in a helicopter or airplane. Generally, the instrumentation records the intensity, location, and spectral analysis of the radiation field.

ALPHA PARTICLE (RADIATION). A helium nucleus consisting of 2 protons and 2 neutrons and having a double positive charge.

ANODE. A positive electrode; an electrode to which electrons or negative ions flow.

ARCHIVED SAMPLES. Environmental samples (sediment and soil) stored for future retrieval or final disposal.

ARITHMETIC MEAN. Average value; sum of the individual data values divided by the number of observations.

ARITHMETIC STANDARD DEVIATION. An index used to quantify the variation within a set of data according to the formula

$$s = \frac{\sqrt{\Sigma (x - \bar{x})^2}}{n-1} ,$$

where

s = standard deviation,
$\underline{x}$ = individual observation,
$\bar{x}$ = arithmetic mean,
n = number of observations.

AUDIT. Investigation into the adequacy of and adherence to established procedures, instructions, specifications, codes, and other applicable contractual and procedural requirements and the effectiveness of implementation.

AUGERED HOLE. A hole produced by an auger drilled into the soil.

BACKGROUND RADIATION. Radiation arising from cosmic rays and natural radioactive sources indigenous to the region, area, or location under consideration.

BASE LINE. The first line laid on a grid system, to which all other grid lines are referenced; usually, the longest line in the grid, preferably along one property boundary.

BECQUEREL. The SI unit of the quantity of radioactive material associated with 1 dps (2.7027×10^{-11} Ci).

BETA PARTICLE. An elementary particle emitted from a nucleus during radioactive decay, having a single electrical charge and a mass equal to that of an electron.

BIASED SAMPLE/MEASUREMENT. Samples/measurements taken from a location where radiation levels or other site characteristics are unusual.

CALIBRATION. The activity of measuring, determining, or verifying the accuracy of measurement by a particular instrument or device in relation to a predetermined standard or reference.

CANDIDATE SITE. Property formerly utilized under contract with MED/AEC and covered by the FUSRAP program; inactive uranium mill sites covered by the UMTRAP program; or surplus DOE contractor facilities owned by the U.S. Government.

CATHODE. A negative electrode; an electrode to which positive ions flow or from which electrons appear to originate.

CERTIFICATE OF COMPLIANCE. A written statement, signed by a qualified party, attesting that the items or services are in accordance with specified requirements and accompanied by additional information to substantiate the statement.

CERTIFICATION. The action of determining, verifying, and attesting in writing to the qualifications or validity of personnel, materials, or measurements.

CERTIFIED TEST REPORT. A written document, approved by a qualified party, that contains sufficient data and information to verify the actual properties of items and the results of all required tests.

CHARCOAL CANISTER. A modified U.S. Army M11 gas canister that uses activated charcoal for absorbing radon gases.

CONTAMINATION. The presence of unwanted radioactive matter.

CONVERSION FACTOR. A mathematically derived factor experimentally determined that converts experimental system response to actual values.

CORE SAMPLE. Soil sample obtained by core drilling.

COUNT (RADIATION MEASUREMENTS. The external indication by a device designed to enumerate ionizing events occurring within a given detector.

DAUGHTER. A nuclide formed by the radioactive decay of another nuclide, which in this context is called the parent.

DECONTAMINATION. The removal of chemical, biological, or radiological contaminants from, or their neutralization on, a person, object, or area to within levels established by governing regulatory agencies.

DESIGNATED SITES. Candidate sites and associated vicinity properties designated by the DOE for inclusion in a remedial action program.

DEVIATION. Written authorization to depart from a particular requirement.

DISINTEGRATION, NUCLEAR. A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom. When large numbers of nuclei are involved, the process is characterized by a definite half-life.

DISTANCE TRANSDUCER. An optical device for measuring the distance traveled by the ORNL-RASA Gamma Scanning Van.

DOCUMENTATION. Any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures, or results.

DOSE. The accumulated radiation delivered to the whole body or a specified part within a specified time interval, originating from an external or internal source.

DOSE COMMITMENT. Dose equivalent, in rem, per microcurie of body intake calculated for a 50-year period.

DOSE EQUIVALENT. Quantity that expresses all radiations on a common scale for calculating the effective absorbed dose; the product of the absorbed dose in rads and certain modifying factors. The unit of dose equivalent is the rem.

DOSE RATE. The radiation dose delivered per unit time (e.g., rads per hour).

EFFICIENCY (COUNTERS). A measure of the probability that a nuclear disintegration will be detected when radiation is incident onto a detector.

ELECTRON VOLT. A unit equivalent to the amount of energy gained by an electron in passing through a potential difference of one volt (1.6×10^{-12} erg).

ENERGY DEPENDENCE. The characteristic response of a radiation detector (e.g., efficiency) over a given range of radiation energies.

EXPOSURE. A measure of the ionization produced in air by X or gamma radiation expressed in roentgens (R).

EXPOSURE PATHWAY. The pathway by which radioactivity travels in the environment to cause radiation exposure to man.

EXPOSURE RATE. Radiation exposure delivered per unit time, normally in roentgens per hour.

EXTERNAL RADIATION. Radiation from a source outside the body.

FIXED CONTAMINATION. Residual radioactive materials that cannot be easily removed from a surface by wiping the area.

FORMERLY UTILIZED SITE. A site once used by or under contract to the Manhattan Engineer District or the Atomic Energy Commission to conduct research with, process, or store uranium or thorium ore or metals derived therefrom.

GAMMA RADIATION. High-energy, short-wavelength electromagnetic radiation having a range of wave lengths from 10^{-9} to 10^{-12} cm.

GAMMA-RAY LOGGING. The process for determining the radioactivity profile of an augered hole.

GAMMA-RAY SCAN. A measure of the gamma radiation level of surfaces using a portable gamma scintillation survey meter.

GAMMA SCANNING VAN. The modified Dodge 300 van that contains and transports the mobile gamma scanning instrumentation.

GAMMA SCINTILLATOR. A crystal detector that emits visible light in proportion to the intensity of a gamma-ray field. The visible light is converted to an electric current by a photomultiplier tube.

GAS FLOW COUNTER. A radiation detector in which an appropriate atmosphere is maintained by allowing a suitable gas to flow slowly through the sensitive detector volume.

GEIGER-MUELLER COUNTER. Highly sensitive, gas-filled radiation-measuring device that operates at voltages sufficiently high to produce multiple ionizations from each interaction with radiation.

Ge(Li) DETECTOR. A radiation detector using a germanium (lithium drifted) crystal used for detecting X or gamma rays.

GEOMETRIC MEAN. The exponential of the mean of the natural log of the values.

$$\bar{x}_g = \exp\left[\sum_i \ln \frac{x_i}{n}\right]$$

GEOMETRIC STANDARD DEVIATION. An index used to define the variability of data associated with the geometric mean:

$$s_g = \exp\left[\sqrt{\frac{\Sigma (\ln x_i)^2 - \frac{(\Sigma \ln x_i)^2}{n}}{n-1}}\right]$$

GRAY. The SI unit of absorbed dose equal to energy imparted by ionizing radiation to a mass corresponding to 1 joule per kilogram (equals 100 rads).

GRID. A network of parallel horizontal and vertical lines forming squares on a map that may be overlaid on a property parcel for the purpose of identification of exact locations.

GRID BLOCK. A square defined by two adjacent vertical and two adjacent horizontal grid lines.

GRID POINT. The intersection of horizontal and vertical grid lines or the intersection of a grid line and the perimeter of a structure.

HALF-LIFE, RADIOACTIVE. Time required for one-half of the radioactive atoms present to disintegrate.

HEALTH PHYSICS. A term in common use for that branch of radiological science dealing with the protection of man from harmful effects of ionizing radiation.

HOT SPOT. A surface area exhibiting above-average radiation levels.

INSPECTION. A phase of quality control by means of examination, observation, or measurement to determine the conformance of materials, supplies, components, parts, appurtenances, systems, processes or structures to predetermined requirements.

INTERNAL RADIATION. Radiation from a source within the body (as a result of deposition of radionuclides in body tissue).

INTRINSIC GERMANIUM DETECTOR. High-purity germanium detector (HPGe). A detector used for measuring X or gamma radiations.

IONIZATION CHAMBER. An instrument that detects and measures ionizing radiation by measuring the electrical current that flows when radiation ionizes gas in a chamber, making the gas a conductor of the electricity.

IONIZING RADIATION. Any radiation (e.g., alpha, beta, or gamma) displacing electrons from atoms or molecules, thereby producing ions.

ISOTOPE. One of several nuclides of an element (hence having the same number protons and the same atomic number, that differ from one another in the number of neutrons and, therefore, mass number. Virtually identical chemical properties are exhibited by isotopes of a particular element.

LETTER REPORT. A document, issued by ORNL-RASA, which has a limited DOE and internal distribution. It is distinguished from an ORNL report in that only ORNL-RASA manager approval is required prior to submittal to DOE.

LINEAR AMPLIFIER. A pulse amplifier for which the output pulse height is proportional to an input pulse height for a given pulse shape, up to the point at which the amplifier overloads.

LOWER LIMIT OF DETECTION. Lowest level of system response that can be statistically differentiated from background.

LOW-LEVEL RADIATION. Radiation that is of such intensity or concentration that it poses a minimal health hazard.

LUCAS CELL. An air sampling device consisting of a 95-mL glass flask coated on the inside with a uniform layer of zinc sulfide and a value system for opening and closing the device; used in taking radon measurements.

MAN-REM. The product of the average individual dose in a population times the number of individuals in the population.

MAXIMUM PERMISSIBLE CONCENTRATION. Values expressed in microcuries per milliliter that represent concentrations which, if maintained continuously, would result in the maximum permissible doses to the critical organs specified by ICRP.

MINIMUM DETECTABLE ACTIVITY. The lowest level of radioactivity that can be measured precisely using a particular device.

MOBILE LABORATORY. ORNL-RASA semitrailer equipped as a free-standing laboratory for onsite survey work.

MOBILE GAMMA SCANNING. Gamma radiation monitoring of vicinity properties using the Mobile Gamma Scanning Van.

MULTICHANNEL ANALYZER. An electronic device for sorting successive signal pulses into parallel amplitude channels.

NATURALLY OCCURRING RADIONUCLIDES. Radionuclides and their associated daughter products produced during the formation of the earth or by interactions of matter with cosmic rays.

NEUTRON ACTIVATION. A technique in which an excited state is produced within the nucleus of an atom by bombarding it with neutrons; used in analysis of certain radionuclides.

NOBLE GAS. Any of a group of rare gases, including helium, neon, argon, krypton, xenon, and sometimes radon, that exhibit great chemical stability and extremely low reaction rates. Also known as inert gas.

NUCLIDE. A general term referring to any nuclear species of the chemical elements that exists for a measurable time.

ORNL CELL. An air sampling device consisting of a 500-mL Lucite cylinder coated inside with a uniform layer of zinc sulfide used in taking radon measurements. determinations. It has a valve for opening and closing the cell.

SUBJECT: INTRODUCTION

ORNL REPORT - TOPICAL. The ORNL topical report is the treatment of a single subject and is the most widely distributed of the reports produced at Oak Ridge National Laboratory. For ORNL-RASA, it is usually a radiological survey report for either a candidate or a vicinity site.

ORNL-TM REPORT. ORNL-TM documents contain preliminary technical information and are distributed both internally and externally. The information represented and the manner of presentation should be suitable for possible abstracting and indexing.

PARENT. A radionuclide that, upon radioactive decay or disintegration, yields a specific nuclide (the daughter) either directly or as a later member of its radioactive series.

PERMISSIBLE DOSE. The amount of radiation that may be received by an individual within a specified period without harmful result to that individual.

PERSONNEL MONITORING. Determination by either physical or biological measurement of the amount of ionizing radiation to which an individual has been exposed, such as by measuring the darkening of a film badge or performing an analysis on urine for specific radionuclides.

PHOTOPEAK. In an energy spectrum of a NAI(Tl) crystal detector, the pulse-height peak resulting from photoelectric effects from the interaction of the detector with gamma rays.

POSTREMEDIAL ACTION SURVEY. A survey performed to verify that radiological contamination has been reduced to the level specified by the appropriate regulatory body.

PRELIMINARY SURVEY. A radiological survey conducted on a site to determine if a radiological hazard exists or the site warrants a more comprehensive radiological survey because of the presence of residual radioactive materials.

PRESSURIZED ION CHAMBER. A pressurized ionization chamber, or ion chamber, is a detector that collects ion pairs formed by the interaction of radiation with high-pressure gases within the chamber.

PRIME CONTRACTOR. A contractor having a direct contract for an entire project and who may, in turn, assign portions of the work to subcontractors.

PROCEDURE. A document that specifies or describes how an activity is to be performed. It may include methods to be employed, equipment or materials to be used, and sequence of operations.

SUBJECT: INTRODUCTION

PROCESSING SITE. As defined in public Law 95-604, Section 101 (6), (1) any site, including the mill, containing residual radioactive materials, at which all or substantially all of the uranium was produced for sale to any Federal agency prior to January 1, 1971, under a contract with any Federal agency, except in the case of a site at or near Slick Rock, Colorado, unless (a) such site was owned or controlled as of January 1, 1978, or is thereafter owned or controlled by any Federal agency or (b) a license (issued by the Nuclear Regulatory Commission or its predecessor agency under the Atomic Energy Act of 1954 or by a State as permitted under Section 274 of such Act) for the production at such site of any uranium or thorium product derived from ores was in effect on January 1, 1978, or was issued or renewed after such date and (2) any other real property or improvement thereon which (a) is in the vicinity of such site and (b) is determined by the Secretary of Energy, in consultation with the Nuclear Regulatory Commission, to be contaminated with residual radioactive materials derived from such site.

PROCUREMENT DOCUMENTS. Contractually binding documents that identify and define the requirements that items or services must meet to be considered acceptable by the purchaser.

PROGENY. Descendants; used to mean the product of radioactive decay of an element; a nuclide remaining after radioactive decay.

PROPORTIONAL COUNTER. Gas-filled radiation detection tube in which the electrical pulse produced is proportional to the number of ions formed in the gas by the incident radiation.

PULSE HEIGHT SELECTOR. A circuit designed to select and pass voltage pulses in a certain range of amplitudes.

PURCHASE ORDER. A legal document binding the vendor and purchaser to the specified terms of the agreement, including, but not limited to, quantity, quality, delivery, and price.

PURCHASER. The organization or organizations responsible for issuance and administration of a contract.

QUALIFIED PROCEDURE. A procedure that incorporates all applicable codes and standards, operating parameters, and engineering specifications and has been proven adequate for its intended purpose.

QUALITY ASSURANCE. Those planned and systematic actions necessary to provide adequate confidence that an item or a facility will perform satisfactorily in service, including those actions that provide a means of controlling, calibrating, and measuring the characteristics of an item or process to established requirements.

RAD. The unit of absorbed dose equal to 100 ergs/g. The rad is a measure of the energy imparted to matter by ionizing particles per unit mass of irradiated material at the point of interest.

RADIATION. The emission and propagation of energy through matter or space by means of electromagnetic disturbances that display both wave-like and particle-like behavior; in this context, the "particles" are known as photons. Also, refers to the energy so propagated. The term has been extended to include streams of fast-moving particles (alpha and beta particles, free neutrons, cosmic radiation, etc.). Nuclear radiation is emitted from atomic nuclei in various nuclear reactions, including alpha, beta, and gamma radiation and neutrons.

RADIATION MONITORING. Continuous or periodic determination of the amount of radiation present in a given area.

RADIATION PROTECTION GUIDELINE. The officially determined radiation doses not to be exceeded without careful consideration. These standards are equivalent to what was formerly called the maximum permissible dose or maximum permissible exposure.

RADIATION SOURCE. Usually, a man-made, sealed source of radioactivity used in calibrations, in teletherapy, in radiography, as a power source for batteries, or in various types of industrial gauges. Machines such as accelerators, and radioisotopic generators, and natural radionuclides may also be considered sources.

RADIATION STANDARDS. Exposure standards, permissible concentrations, rules for safe handling, regulations for transportation, regulations for industrial control of radiation, and control of radiation exposure by legislative means.

RADIOACTIVE WASTE. Equipment and materials from nuclear operations that are radioactive and for which there is no further use. Wastes are generally classified as high level (having radioactivity concentrations of hundreds to thousands of curies per gallon or cubic foot), low level (in the range of 1 μCi/gal or ft^3), or intermediate level (between these extremes).

RADIOACTIVITY. The property of some elements to spontaneously emit alpha, beta, or gamma rays by the disintegration of the nuclei of atoms.

RADIOISOTOPE. A radioactive isotope; an unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. More than 1300 natural and artificial radioisotopes have been identified.

RADIOLOGICAL SURVEY. The process of measuring the various radiation levels associated with a specified site and the proper documentation and evaluation of the data.

RADIONUCLIDE. Any radioactive species of atom that exists for a measurable length of time. Individual radionuclides are distinguished by their atomic weight and atomic number.

RADIUM. A naturally occurring radionuclide having the atomic number 88.

RADON. The heaviest element of the noble gas group that is produced as a gaseous emanation from the radioactive decay of radium. Its atomic number is 86. All isotopes are radioactive. The isotope Rn-222 has a half-life of 3.82.

RADON CALIBRATION CHAMBER. Enclosure used in the calibration of Wrenn Chambers in association with a radon source, transfer lines, sampling ports, humidity measuring devices, and air purge systems.

RADON FLUX. The number of radon atoms migrating across a unit area within a specified time.

RANDOM SAMPLE/MEASUREMENT. Samples/measurements taken in which no specific consideration is given to the exact sampling/measurement location.

REM. Unit of dose equivalent; that quantity of any type of ionizing radiation that, when absorbed by man, produces equivalent specific biological effect to that produced by 1 rad of 250 keV X rays.

REMEDIAL ACTION. The activity of removing radioactive material or otherwise decontaminating candidate sites or vicinity properties.

REMEDIAL ACTION SITE. As defined in the Residual Radioactive Material Control Act, (1) a site at which remedial action is required and which was used under a contract with any predecessor of the Department of Energy, including the Manhattan Engineer District and Atomic Energy Commission for researching, developing, manufacturing, fabricating, testing, processing, sampling, or storing radioactive material, except a site (a) for which a license (issued by the Nuclear Regulatory Commission or its predecessor agency under the Atomic Energy Act of 1954, or by a State under Section 274 of that Act) for the production or possession at the site of uranium or thorium, their daughter products, including radium, is in effect on the date of enactment of the Residual Radioactive Material Control Act, or is issued or renewed after that date or (b) owned or leased by the Federal Government on or after the date of enactment of the Residual Radioactive Material Control Act and (2) any other location the Secretary of Energy or his designee determines to require remedial action due to contamination with residual radioactive material derived from a site meeting the criteria of part (1) of this definition.

REPORT. A document that gives information for record purposes.

RESIDUAL RADIOACTIVE MATERIAL. Material (including but not limited to waste material, soils, rocks, plants, shrubs, personal property, and building materials) present at a site that results in radiation levels that exceed background levels.

RESIDUE. Material that remains after some fraction is removed.

RESTRICTED USE. A designation following remedial action that requires some control on the activities at a site containing radioactive material.

ROENTGEN. The quantity of X or gamma radiation that will produce (in 0.001293 air at standard temperature and pressure) ions carrying 1 electrostatic unit of electricity of either sign.

SCATTERED RADIATION. Radiation which, during its passage through a substance, has been modified in direction and, usually, in energy.

SCINTILLATION COUNTER. The combination of phosphors, photomultiplier tube, and associated circuits for counting light emissions produced in the phosphors by incident ionizing radiation.

SI. International System of Units.

SIEVERT. An SI unit of dose equivalent that represents the absorption of 1 J/kg. One sievert equals 100 rem.

SITE LOG BOOK. May be either a field data, radon data, or scanning van log book.

SMEAR COUNTER. A nuclear radiation counter used to count smear samples to determine the amount of transferable radioactivity on surfaces.

SMEAR SAMPLE. A sample taken by "smearing" a piece of filter paper over suspected areas of surface contamination.

SODIUM IODIDE DETECTOR. A detector that uses a sodium iodide (thallium activated) crystal for detecting gamma rays.

SPECIFIC ACTIVITY. The total radioactivity or that attributable to an identified nuclide per gram of specified material.

SPECIFICATION. A concise set of requirements to be satisfied by a product, material, or process; indicating, whenever appropriate, the procedure by which satisfaction of the requirements may be determined.

SPECTRUM. A visual display, photographic record, or plot of the distribution of the intensity of a given type of radiation as a function of its wavelength, energy, frequency, momentum, mass, or any related quantity.

STANDARD. The result of a particular standardization effort approved by a recognized authority.

SUBCONTRACTOR. A manufacturer or organization that receives a contract from a prime contractor for a portion of the work on a project.

SUBSURFACE SOIL SAMPLE. Soil sample taken from deeper than 6 in. below the soil surface level.

SURFACE BARRIER DETECTOR. A type of semiconductor detector, such as silicon, having a depletion region in the crystal and a thin gold film electrode.

SURFACE SOIL SAMPLE. Soil sample taken from the first 6 in. of surface soil.

SURVEY METER. Any portable radiation detecting instrument especially adapted for surveying or inspecting an area to establish the existence of radioactive material.

SURVEY PLAN. A radiological survey plan for determining the radiological characteristics of a specific site.

SYSTEMATIC SAMPLE/MEASUREMENT. Samples/measurements taken under a definite method or plan.

TAILINGS. As defined in Public Law 95-604, Section 101(8), the term "tailings" means the remaining portion of a metal-bearing ore after some or all of such metal, such as uranium, has been extracted.

THORIUM. A naturally radioactive element having atomic number 90 and, as found in nature, an atomic weight of approximately 232. The ^{232}Th isotope is abundant and can be transmuted to fissionable ^{232}U by neutron irradiation.

TITLE I ENGINEERING. The phase of engineering associated with planning, evaluating, and scheduling.

TITLE II ENGINEERING. The phase of engineering associated with more detailed activities such as drawings, specifications tests, and calculations.

TRANSFERABLE CONTAMINATION. Radioactive contamination that can be transferred by contact with the contaminated object.

SUBJECT: INTRODUCTION

UNRESTRICTED USE. Any use without restraint on ownership, occupancy, or land development.

URANIUM. A radioactive element having the atomic number 92 and, as found in natural ores, an average atomic weight of approximately 238. The two principal natural isotopes are ^{235}U (0.7 % of natural uranium) and ^{238}U (99.3 % of natural uranium). Natural uranium also includes a minute amount of ^{234}U. Uranium is the basic raw material of nuclear energy.

URANIUM MILL TAILINGS SITE. A site used in the handling, processing, or storage of uranium ores and their residues.

VERIFICATION. A documented act of confirming, substantiating, and assuring that an activity or condition has been implemented in conformance with the specified requirements.

VICINITY PROPERTIES. Public or private properties in the vicinity of candidate sites (FUSRAP or UMTRAP) in the RASA program.

WATER SAMPLES. Samples of surface or subsurface water removed from a survey site for the purpose of chemical, physical, or radiological analysis.

WATER SEDIMENT SAMPLE. Sample taken of materials (soil, gravel, etc.) deposited under a surface water body for the purpose of chemical, physical, or radiological analysis.

WORKING LEVEL. Any combination of short-lived ^{222}Rn progeny in 1 L of air such that the ultimate emission of alpha particle energy is 1.3×10^5 MeV.

WRENN CHAMBER. A device used for measuring radon gas concentrations in air by diffusion and direct nuclide counting.

X RADIATION. Electromagnetic radiation having wavelengths shorter than those of visible or ultraviolet light and originating from electron energy level transfers outside the nucleus of an atom.

ZnS DETECTOR. A detector using ZnS (zinc sulfide) powder as the detection medium and used for detection of alpha particles or other heavy ions.

1.5.2 Abbreviations

Standard prefixes may be used with unit abbreviations.

m	milli	10^{-3}	k	kilo	10^{3}
μ	micro	10^{-6}	M	mega	10^{6}
n	nano	10^{-9}	G	giga	10^{9}
p	pico	10^{-12}	T	tera	10^{12}
f	femto	10^{-15}	P	peta	10^{15}
a	atto	10^{-18}	E	exa	10^{18}

Other standard abbreviations are:

alpha	α	gram	g
becquerel	Bq	gray	Gy
beta	B	hectare	ha
centigrade	C	hour	h
counts per minute	cpm	inches	in.
cubic feet	ft^3	liter	L
cubic meters	m^3	meter	m
curie	Ci	metric ton	MT
disintegrations per minute	dpm	minute	min
electron volt	eV	roentgen	R
feet	ft	second	s
gamma	γ	working level	WL

1.5.3 Acronyms

AEC Atomic Energy Commission

ALARA as low as reasonably achievable

ANSI American National Standards Institute

DOE Department of Energy

EPA Environmental Protection Agency

FUSRAP Formerly Utilized Sites Remedial Action Program

Ge(Li) Lithium-drifted germanium

GJRAP Grand Junction Remedial Action Program

GM Geiger-Mueller

HASRD Health and Safety Research Division

HPGe	high-purity germanium
ICRP	International Commission on Radiological Protection
LLD	lower limit of detection
MED	Manhattan Engineer District
MDA	minimum detectable activity
MPC	maximum permissible concentration
NaI	sodium iodide
NBL	New Brunswick Laboratory
NBS	National Bureau of Standards
NEPA	National Environmental Policy Act
NRC"	Nuclear Regulatory Commission
OOS	Office of Operational Safety
ORAU	Oak Ridge Associated Universities
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations Office
PIC	pressurized ion chamber
QA	quality assurance
RASA	Radiological Survey Activities
UMTRAP	Uranium Mill Tailings Remedial Action Program

1.6 USE OF MANUAL

This manual describes the functions and procedures used at ORNL in support of the RASA program as implemented for the DOE. The format and arrangement of the manual was selected to facilitate its use and to enable revisions to be incorporated simply and easily. The manual is intended to be used as a reference for all operations related to the ORNL-RASA program and may also, from time-to-time, serve as a training manual.

SUBJECT: INTRODUCTION

To ensure the integrity of the manual, *individual procedures or sections should not be removed or used out of context.* The manual is intended to be used as a complete entity to assure consistency in radiological measurements and to enhance their credibility. To this end, copies of the manual are provided at all appropriate work stations (e.g., field vehicles, trailers, laboratories, offices, etc.) as well as to individuals having significant responsibilities in the implementation of ORNL-RASA operations.

The ORNL-RASA Procedures Manual consists of some 21 major sections, each of which contains one or more subsections or procedures. Section 1 (Introduction) is descriptive in nature and defines the purpose, scope, and use of the manual and includes a policy statement on QA. A master glossary of terms used in this manual is also included in Sect. 1. Section 2 (Integrated Activity Functional Description) provides background information on the functions and administration of the ORNL-RASA program. Both of these sections may be consulted occasionally for general information and should be reviewed in the course of any related orientation or training program.

Sections 3 through 9 are "control" or planning sections and are intended to provide procedural guidance in the planning and administration of activities related to a particular survey project. Normally, authorization to perform a survey would be received by the ORNL-RASA program manager who would utilize the procedures in Sect. 3 (Program Administration), initiate a project, and identify the general requirements and nature of the specific survey. Depending on the type of survey required, Sect. 4 (Preliminary Survey Planning), Sect. 5 (Vicinity Properties Survey Planning), Sect. 6 (Candidate Site Survey Planning) or Sect. 7 (Postremedial Action Survey Planning) would be used to develop the specific survey plan. These sections are general in nature to allow the flexibility necessary to adapt the survey plan to the specific requirements of a designated site. Section 8 (Support Function Planning) provides general guidance for identification and planning of support functions, as required, and Sect. 9 (QA Planning) provides the basis for the ORNL-RASA Quality Assurance Program.

Sections 3 through 9 are intended primarily for use by the ORNL-RASA program manager, the designated site leaders, and the individual assigned responsibility for QA activities. Detailed implementing procedures for ORNL-RASA activities are provided in Sects. 10 through 21. These sections are arranged according to general categories of activity, as follows:

Section	Activity
10	Project Management
11	Pre-Survey Activities
12	Mobile Gamma Scanning Van
13	Field Measurements
14	Sample Collection
15	Laboratory Analyses

SUBJECT: INTRODUCTION

Section	Activity
16	Equipment Inventory Control and Maintenance
17	Monitoring and Decontamination
18	Subcontract Services and Administration
19	QA Procedures
20	Measuring and Test Equipment Calibration
21	Computer Operation

Each of these sections provides a number of individual procedures detailing specific activities/measurements performed by the ORNL-RASA group. These procedures should be consulted by the staff members, as appropriate, in the performance of specific assignments and responsibilities as designated by the ORNL-RASA program manager or the assigned site leader.

2. INTEGRATED ACTIVITY FUNCTIONAL DESCRIPTION

SUBJECT: INTEGRATED ACTIVITY FUNCTIONAL DESCRIPTION

2. INTEGRATED ACTIVITY FUNCTIONAL DESCRIPTION

2.1 ORNL-RASA PROGRAM ADMINISTRATION

The DOE OOS specifies all radiological surveys and postremedial action reviews to be performed under the ORNL-RASA program. The DOE OOS, acting through the ORO Energy Programs and Support Division, specifies the sites and vicinity properties to be surveyed, defines the priority of the survey activities, approves the ORNL-RASA survey plans, coordinates the onsite survey activities, and reviews the survey documents before publication. The OOS coordinates with the DOE Remedial Action Program Office (RAPO), which is responsible for the remedial actions to be undertaken at the sites and properties, for all post-remedial action reviews to be performed by the ORNL-RASA program.

The responsibility for the detailed planning, conducting, and reporting of radiological surveys has been assigned to the RASA group of the Dosimetry and Biophysical Transport Section (DABTS) of the Health and Safety Research Division (HASRD). For efficiency, the positions of ORNL-RASA program manager and RASA group leader have been combined. Dual paths of responsibility and accountability are shown in Exhibit 2.1.

The organizational structure for administrative reporting to the DOE includes the DABT Section Head, the HASRD Division Director, the ORNL Assistant Director for Biomedical and Environmental Programs, and the ORNL Laboratory Director. This structure is used to submit formal RASA reports and documents, to procure material items and subcontractor services, and to obtain support services from other ORNL divisions that are necessary to conduct the RASA program. The legal control point for obtaining services and materials from a subcontractor and support from other ORNL Divisions is the HASRD Division Director.

The structure for programmatic reporting to DOE is directly from the ORNL-RASA program manager to the DOE ORO office, Director of the Energy Programs and Support Division. This reporting line is used to submit informal RASA reports and documents, to plan and coordinate specific RASA activities, and to report on progress.

The support divisions indicated in Exhibit 2.1. provide necessary services as required to support the RASA program activities. Basic support service agreements are obtained through the Administrative Organization. Once established, the ORNL-RASA program manager coordinates the specific work requirements and receives the requested output products and services directly from the support divisions.

2.2. ORNL-RASA PROGRAMMATIC ORGANIZATION AND ACTIVITIES

The seven major program-oriented activities of the ORNL-RASA group conducted in support of the DOE-RASA program are

1. Screening surveys of major sites
2. Radiological surveys of major sites
3. Postremedial Action (PRA) reviews of major sites
4. Mobile gamma scanning surveys of properties in the vicinity of the major sites
5. Radiological surveys of vicinity properties
6. PRA reviews of vicinity properties
7. Health and safety overview support

The generic structure for conducting the surveys and PRA reviews is illustrated in Exhibit 2.1.

The requirements for performing the screening and radiological surveys of the candidate sites and the mobile gamma scanning and radiological surveys of the vicinity properties are defined by the DOE OOS. Such survey activities are performed via the organization shown in Exhibit 2.2. The results of the surveys performed by ORNL-RASA are used by OOS to designate the sites and properties for remedial action.

PRA reviews for the candidate sites and vicinity properties are performed via the organization shown in Exhibit 2.3. ORNL-RASA performs the reviews at the request of OOS, interfacing with RAPO through the Assistant Secretary for Environmental Protection, Safety, and Emergency Preparedness (ASEP) and the Assistant Secretary for Nuclear Energy (ASNE). The DOE RAPO is responsible for the determination of remedial action priorities and for performing the necessary remedial actions.

The assigned work is performed by the RASA group with support from other ORNL divisions and subcontractor personnel. In the programmatic organization, the ORNL-RASA program manager, which is a combined position with the RASA group leader, organizes and contracts the assigned work, coordinates and schedules the survey and analysis activities, assigns personnel, and provides for the programmatic reporting of the RASA activities to the DOE OOS through the ORO Energy Programs and Support Division. The reporting line is illustrated in Fig. 2.2.

The work assigned by the DOE OOS is organized into individual projects or special tasks to be implemented by the RASA personnel. Following the assignment of a survey or PRA review responsibility, the program manager assigns responsibility for the necessary work to a site leader. The responsibility for planning the survey activities, conducting the onsite survey, performing the analysis of the survey data, preparing the survey reports, and providing continuity for an assigned site or set of vicinity properties are delegated to the site leader. The site leader will draw on the RASA resources as necessary to perform the assigned work.

SUBJECT: INTEGRATED ACTIVITY FUNCTIONAL DESCRIPTION

The generic RASA program functions that are performed by RASA personnel are listed on Exhibit 2.4. RASA personnel are appropriately trained to perform one or more of the specified functions. The identified staff positions for performing the ongoing program management and office operations work are listed on Exhibit 2.5. RASA personnel are assigned to perform the periodic site survey tasks on a project-by-project basis to perform the work associated with survey activity as required. The site leader will define the RASA personnel and facility resources required to perform the assigned work and will assist the ORNL-RASA program manager in establishing appropriate teams and schedules for performing the work. A flow chart illustrating the program activities is provided in Exhibit 2.6. The flow chart indicates all survey planning and implementation activities, following DOE site identification and assignment, which are performed by RASA personnel.

2.3. ORNL-RASA ADMINISTRATIVE ORGANIZATION

The DOE-RASA program at ORNL is conducted exclusively by ORNL-RASA in the Dosimetry and Biophysical Transport Section (DABTS) of the Health and Safety Research Division (HASRD) of ORNL. See ORNL-RASA Administrative Organization (Exhibit 2.1). Its sole function is to respond to the needs of DOE.

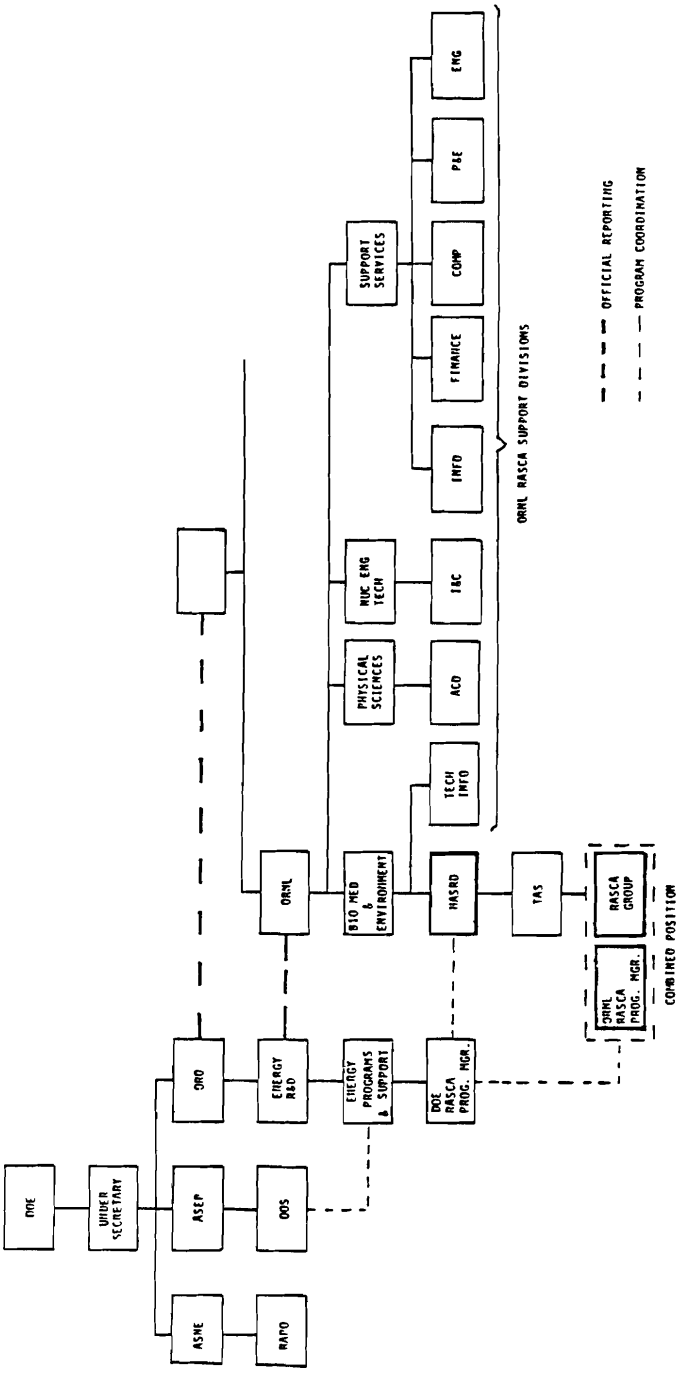
Administratively, the ORNL-RASA group is headed by the ORNL-RASA group leader, which is a combined position with that of the ORNL-RASA program manager. In the combined position, all technical and office staff members report directly to the ORNL-RASA program manager. The ORNL-RASA program manager reports to the DABT section head, who reports to the HASRD division director. The HASRD division director reports to the ORNL Associate Director of Biomedical and Environmental Programs, who reports to the ORNL Laboratory Director. Administrative interaction between ORNL and DOE is achieved through the ORNL Laboratory Director to the Deputy Manager for R&D at the DOE ORO office.

Administrative management of ORNL-RASA is performed in accordance with Martin Marietta Energy Systems, Inc. Administrative Procedures as described in "D" Series Standard Practice Procedures.

Sole funding for the ORNL-RASA program is administered by the DOE Assistant Secretary for Environmental Protection, Safety and Emergency Preparedness through the DOEOOS. Funding is directed to Martin Marietta Energy Systems, Inc. through the ORO of DOE.

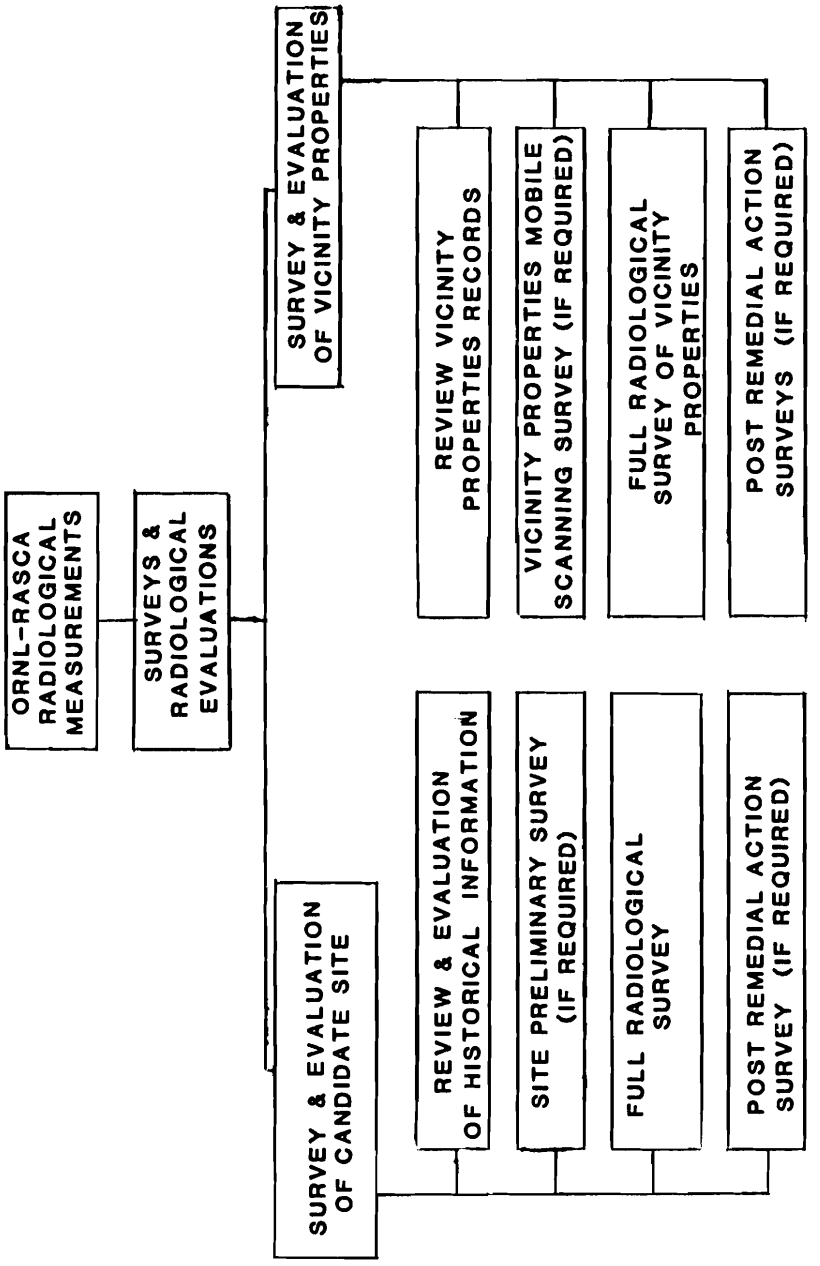
SUBJECT: INTEGRATED ACTIVITY FUNCTIONAL DESCRIPTION

Exhibit 2.1. ORNL-RASA program administration.



SUBJECT: INTEGRATED ACTIVITY FUNCTIONAL DESCRIPTION

Exhibit 2.2. ORNL-RASA generic survey structure (functions and activities.



SUBJECT: INTEGRATED ACTIVITY FUNCTIONAL DESCRIPTION

Exhibit 2.3. Programmatic organizational chart.

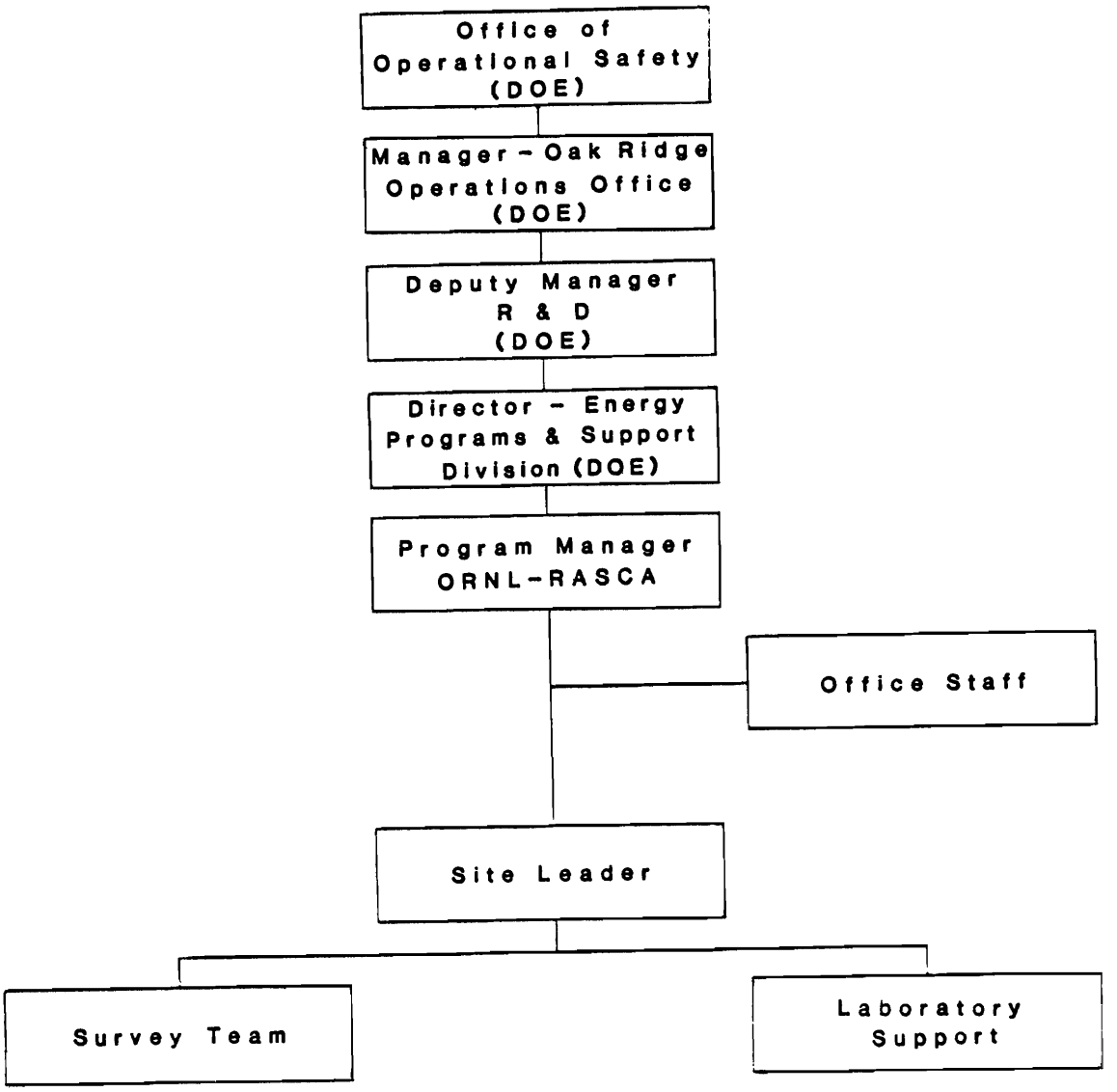
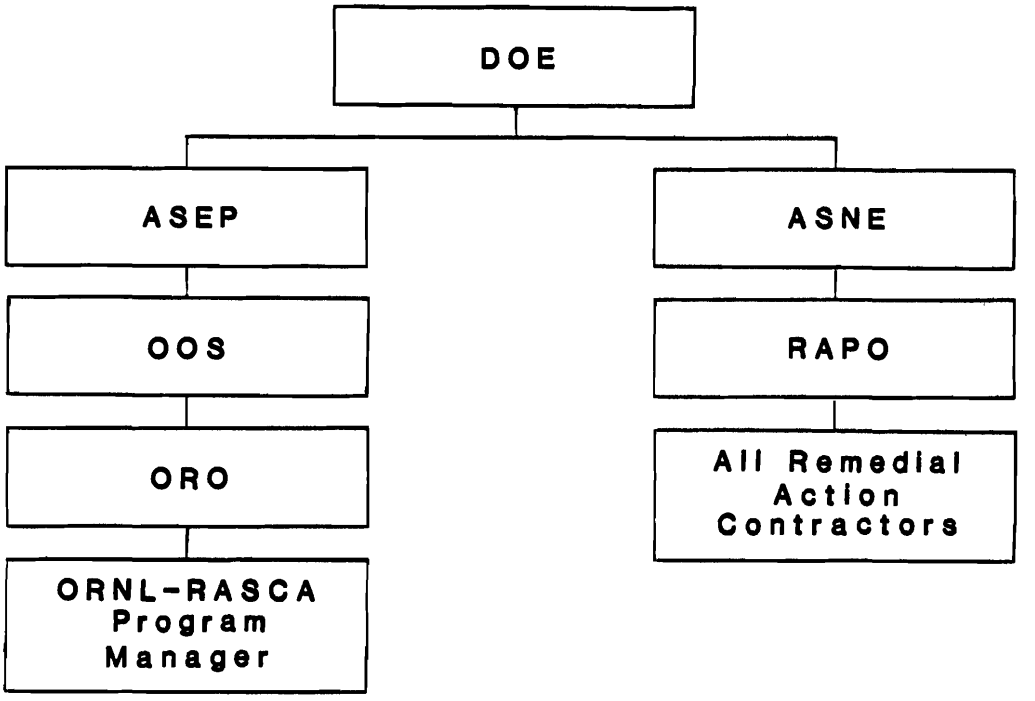


Exhibit 2.4. ORNL-RASA remedial action interface.



SUBJECT: INTEGRATED ACTIVITY FUNCTIONAL DESCRIPTION

Exhibit 2.5. Generic RASA program functions.

Program Management and Office Operations

ORNL-RASA Program Management
ORNL-RASA Office Operations
Subcontract Direction and Management
Records Management
- Environmental Samples
- Survey Records and Archives
- Photographic Files
- Equipment Inventory, Files and Maintenance
- Administrative Records

Personnel Safety
Program Quality Assurance
Calibration Source Maintenance and Records
Portable Survey Instrumentation Maintenance
Instrument Calibration and Service Records
Mobile Laboratory Maintenance
Mobile Scanning Van Maintenance
Gamma Spectroscopy Equipment Maintenance
Sample Receiving Documentation

Site Survey Operations

Survey Team Leadership
Site Survey Planning
Survey Grid System Preparation
Radiological Measurements Collection and Reporting
Boring and Coring Operations
Environmental Samples Collection and Reporting
Radon and Radon Daughter Measurements and Reporting
Sample Preparation
Gamma-ray Spectral Analysis of Soil Samples
Analyses of Water and Sediment Samples
Radiochemical Analysis
Hydrologic and Geologic Data Collection and Reporting
Radiation Exposure Evaluation
Mobile Scanning Van Operation
Survey Report Writing
Survey Report Graphics Preparation
Report Typing
Report Coordination

Exhibit 2.6. ORNL-RASA staff positions.

Staff positions

Program Manager
Site Leader
QA Coordinator
Instrument Technologist
Records Technologist
Calibration Records Technologist
Office Manager
Secretary
Mobile Laboratory Coordinator
Laboratory Technologist

3. PROGRAM ADMINISTRATION

SUBJECT: PROGRAM ADMINISTRATION

3. PROGRAM ADMINISTRATION

3.1 PURPOSE

The purpose of this procedure is to provide information relevant to the ORNL-RASA program project management.

3.2 APPLICABILITY

This procedure applies to all ORNL-RASA program projects.

3.3 REFERENCES

1. Sect. 4.1, Preliminary Survey Planning
2. Sect. 5.1, Preparation of Vicinity Properties Survey Plan
3. Sect. 5.2, Preparation of Mobile Scanning Survey Plan
4. Sect. 6.1, Preparation of Candidate Site Survey Plan
5. Sect. 7.1, Preparation of Postremedial Action Survey Plan
6. Sect. 8.1, Identification and Planning of Support Functions
7. Sect. 9.1, QA Planning
8. Sect. 10.1, Project Organization and Scheduling
9. Sect. 10.5, Reports and Papers
10. Sect. 11.1, Evaluation of Site Records and Data

3.4 DEFINITIONS AND ABBREVIATIONS

3.4.1 Definitions

PROGRAM. The ORNL-RASA program as conducted for DOE.

PROJECT. All radiological survey activities dealing with a single candidate site or set of vicinity properties.

Also see Sect. 1.5 of this manual, Terminology.

3.4.2 Abbreviations

ORAU Oak Ridge Associated Universities.

Also see Sect. 1.5 of this manual, Terminology.

APPROVED: _____ DATE: _____
RASA Program Manager

3.5 RESPONSIBILITIES

The ORNL-RASA program manager is responsible for the implementation of this procedure and for the overall ORNL-RASA program management. Each site leader is responsible for the overall project management, excluding those items of responsibility retained by the ORNL-RASA program manager.

3.6 PROCEDURE

3.6.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for the overall management of the program. Management activities include:

1. Assigning a site leader to a project
2. Setting project priority and milestone schedule for performing the project
3. Establishing and controlling the project budget
4. Assigning personnel to perform survey and laboratory tasks
5. Preparing weekly and monthly reports to DOE concerning project activities
6. Reviewing and approving all project-related reports prior to submission to DOE
7. Setting project priority and time constraints in conjunction with DOE
8. Controlling use of ORNL support divisions and subcontractor personnel

3.6.2 Site Leader

The site leader has the primary responsibility for project management at a specific site. This includes the following items.

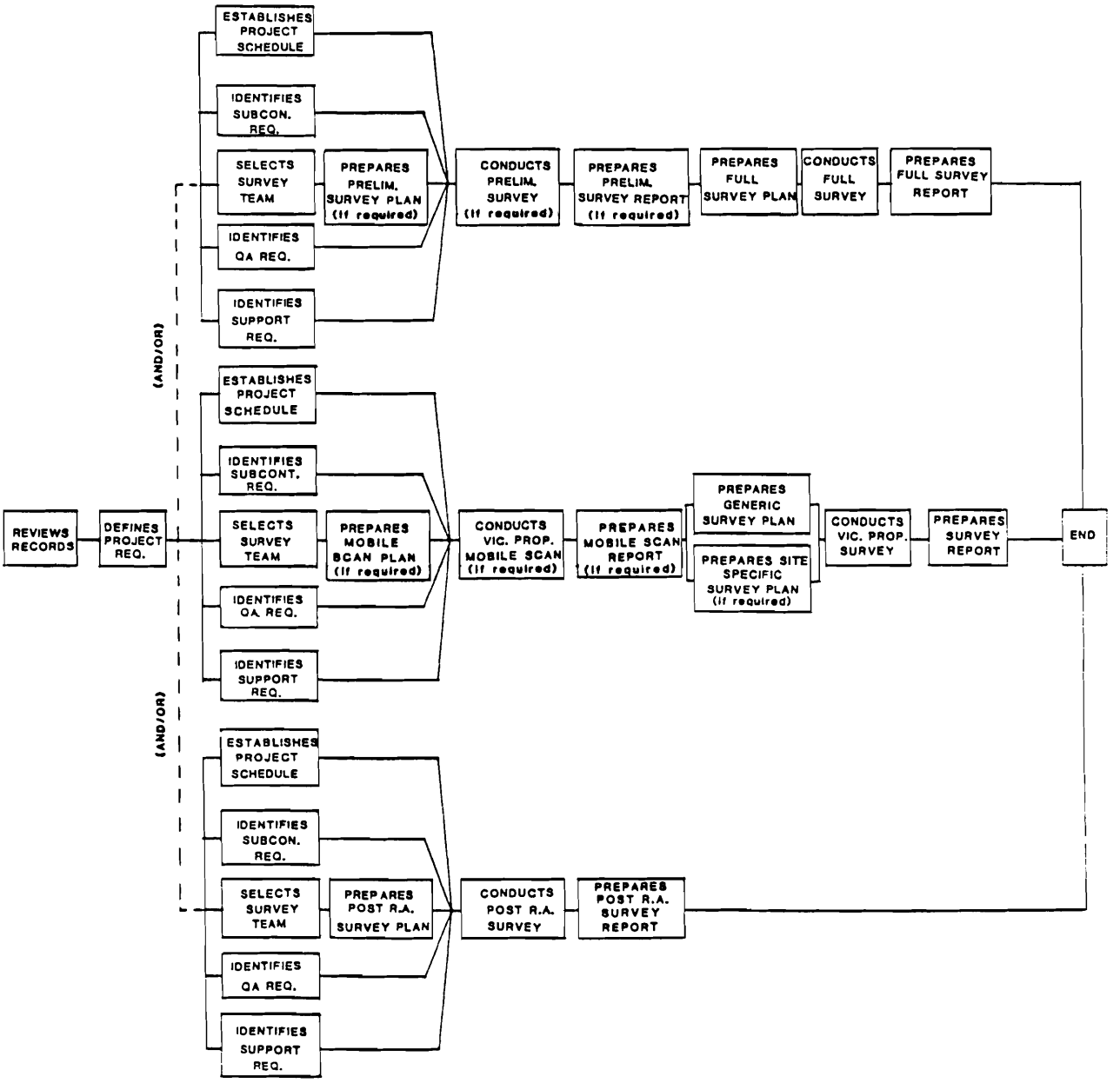
1. Reviews site-related historical records to assist in estimating the size of the project; the information is used to determine subcontractor requirements, survey team size, and survey planning and scheduling according to the procedures of Sect. 11.1, Evaluation of Site Records and Data.
2. Prepares Preliminary Survey Plan according to the procedures of Sect. 4.1, Preliminary Survey Planning.
3. Defines project requirements including manpower, equipment, subcontractors, and time constraints.
4. Establishes project schedule within time constraints imposed by DOE through the ORNL-RASA program manager, including subcontractor scheduling to effect a timely interface between subcontractor and survey team activities according to the procedure of Sect. 10.1, Project Organization and Scheduling.

5. Prepares Candidate Site Survey Plan for a full radiological site survey according to the procedure of Sect. 6.1, Preparation of Candidate Site Survey Plan.
6. Prepares Vicinity Properties Survey Plan (if applicable) according to the procedure of Sect. 5.1, Preparation of Vicinity Properties Survey Plan.
7. Prepares Mobile Scanning Survey Plan (if applicable) according to the procedure of Sect. 5.2, Preparation of Mobile Scanning Survey Plan.
8. Prepares Postremedial Action Survey Plan (if applicable) according to the procedure of Sect. 7.1, Preparation of Postremedial Action Survey Plan.
9. Identifies support function requirements according to the procedure of Sect. 8.1, Identification and Planning of Support Functions, including activities involving ORAU, and preparation of necessary purchase orders and other documentation.
10. Identifies QA requirements and prepares QA plans according to the procedure of Sect. 9.1, QA Planning.
11. Generates all plans and reports pertinent to the assigned project according to the procedure of Sect. 10.5, Reports and Papers.
12. Plans and coordinates all field activities and task assignments for the project.
13. Assists program manager in selection of survey team members based on project requirements, specific individual expertise, and the availability of ORNL-RASA personnel.

Chronological order of activities involving project management are illustrated in the Project Management Flow Sheet (Exhibit 3.1). These activities are shown grouped as Candidate Site, Vicinity Properties, and Postremedial Action Survey and have an "and/or" relationship in which each individual activity or any combination may be considered a project.

SUBJECT: PROGRAM ADMINISTRATION

Exhibit 3.1. Project management flow sheet.



4. PRELIMINARY SURVEY PLANNING

SUBJECT: PRELIMINARY SURVEY PLANNING

4. PRELIMINARY SURVEY PLANNING

4.1 PURPOSE

The purpose of this procedure is to provide a method for the organized planning of activities preceding the preliminary survey of a candidate site.

4.2 APPLICABILITY

This procedure applies to all preliminary surveys conducted by ORNL in support of the DOE-RASA program.

4.3 REFERENCES

1. Sect. 6.2, Preparation for and Performance of Surveys
2. Sect. 11.1, Evaluation of Site Records and Data

4.4 DEFINITIONS AND ABBREVIATIONS

4.4.1 Definitions

PRELIMINARY SURVEY. A radiological survey performed to establish the presence of contamination, to provide input for the decision by DOE to conduct a full radiological survey, and to obtain site information needed for the planning of the comprehensive survey.

INITIAL SITE VISIT. Preliminary survey.

Also see Sect. 1.5 of this manual, Terminology.

4.4.2 Abbreviations

AEC Atomic Energy Commission.

MED Manhattan Engineer District.

Also see Sect. 1.5 of this manual, Terminology.

4.5 RESPONSIBILITIES

The site leader is responsible for the implementation of this procedure and has overall responsibility of the project; responsibility for report review and submittal remains with the RASA program manager.

APPROVED: _____ DATE: _____
RASA Program Manager

SUBJECT: PRELIMINARY SURVEY PLANNING

4.6 PROCEDURE

4.6.1 Document Review

A thorough review of all available documents pertinent to an assigned candidate site or vicinity property shall be made by the site leader. These documents may include:

1. Site plats
2. Site blueprints and drawings
3. Site photographs
4. All available drawings and sketches concerning structures located on the site
5. Radiological survey results (including DOE aerial surveys) and any data acquired prior to decontamination activities
6. Aerial photos
7. Maps
8. Current site usage data

Historical site documents are provided to ORNL-RASA by DOE. Additional information is contained in the procedure of Sect. 11.1, Evaluation of Site Records and Data.

4.6.2 Interviews

DOE makes the initial contact with the property (site) owners. ORNL-RASA personnel may directly contact the property owner(s) only at the discretion of DOE.

In contacting the property owner(s), the site leader will determine if any persons currently at the site were associated with the operations and activities on the site during the period of active involvement in MED or AEC activities.

Personal interviews with these people may provide additional input into the evaluation of requirements for the preliminary survey. Documentation of these interviews shall be placed in the Preliminary Survey Plan file.

4.6.3 Planning Objective

The basic objective in the Preliminary Survey Planning is to determine, as exactly as possible, what happened at the site. Results of the historical reviews and personal interviews should be assembled in concise form to assist in preparation of the Preliminary Survey Plan. The following are typical questions designed to provide the desired information:

1. Who did the original work?
2. What were the starting materials, intermediates, and end products?
3. Where was the process located on the site?
4. Where were raw material and product storage areas?
5. What was the production flow path of radioactive material through the site?
6. What buildings and equipment were used in the process?
7. Is equipment formerly used in the process located on the site, and where is it located?
8. Is there a possibility of offsite contamination by natural or anthropogenic means?
9. What areas have been previously subjected to decontamination, and what were the results of those activities?

4.6.4 Preliminary Survey Determinations

Based on evaluation of the data as assembled following Sect. 6.3 of this procedure, determine as applicable:

1. Which property area(s) are to be surveyed?
2. Which building(s) are to be surveyed (include specific room if possible)?
3. What measurements should be made?
4. Where should measurements be taken?
5. What samples should be taken to reflect representative site characteristics?
6. Which analyses should be performed on the samples?
7. What site photographs should be made?
8. What additional equipment will be required? (See Preliminary Survey Equipment List, Exhibit 4.1).
9. Will additional personnel be needed above the normal preliminary survey complement of two?

Exhibit 4.1. Preliminary survey equipment list.[a]

Equipment
Gamma scintillation detectors
Beta-gamma detectors
Alpha detectors
Soil bags and scoops
Water containers
Smear equipment
Blank log book
Photographic equipment

[a]Normally two of each primary piece of equipment is taken to a survey site.

5. VICINITY PROPERTIES SURVEY PLANNING

SUBJECT: VICINITY PROPERTIES SURVEY PLANNING

5. VICINITY PROPERTIES SURVEY PLANNING

5.1 PREPARATION OF VICINITY PROPERTIES SURVEY PLAN

5.1.1 Purpose

The purpose of this procedure is to provide guidelines for preparing a Vicinity Properties Survey Plan.

5.1.2 Applicability

This procedure applies to the preparation of a vicinity properties radiological survey plan by the ORNL-RASA personnel. Refer to the procedures of Sect. 6.2, Preparation for and Performance of Surveys.

5.1.3 References

1. Sect. 6.1, Preparation of Candidate Site Survey Plan
2. Sect. 6.2, Preparation for and Performance of Surveys
3. Sect. 10.5, Reports and Papers
4. Sect. 12.1, Mobile Gamma Scanning Van Operation
5. Vicinity Properties Preliminary Site Survey Report

5.1.4 Definitions and Abbreviations

See Sect.1.5 of this Manual, Terminology.

5.1.5 Responsibilities

5.1.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager has the overall responsibility of the Vicinity Properties Survey Plan. He will designate a site leader and reviewers for the survey plan preparation and review. He is also responsible for reviewing, transmitting, and coordinating the review of the plan and submitting it for DOE review and approval.

5.1.5.2 Site Leader

The site leader is responsible for the development of the Vicinity Properties Survey Plan. He will submit the plan into the review process, resolve comments, and submit the plan to the ORNL-RASA program manager for approval.

APPROVED: _____ DATE: _____
RASA Program Manager

5.1.5.3 Reviewers

The reviewers, assigned by the ORNL-RASA program manager, are responsible for the review of the Vicinity Properties Survey Plan to assure that the plan is prepared in accordance with administrative, operational, and QA requirements. Review comments will be returned to the site leader within three days of receipt of the plan.

5.1.6 Procedure

The procedure for preparation of a vicinity properties radiological survey plan is similar to the procedures of Sect. 6.1, Preparation of a Candidate Site Survey Plan. The main difference is that a vicinity property has been contaminated through introduction of radioactive materials from a candidate site, rather than from actual onsite processing or material handling. As such, vicinity properties do not have the facilities or equipment associated with former processing activities. These sites are usually contaminated to a lesser extent than the candidate site from which the material came.

5.1.6.1 Vicinity Properties Identification

The identification of the vicinity properties will either be provided by DOE based on historical data, aerial survey results, or the mobile scanning survey detailed in Sect. 12.1, Mobile Gamma Scanning Van Operation. All references to the property locations in the survey plan will be made according to the property identification code given by DOE. No direct identification of addresses or property owners will be made. For plans designed to cover the general survey requirements of numerous properties (i.e, for all surveying in a particular city), specific locations may not be included.

5.1.6.2 Determine Potential Exposure Pathways

Refer to Sect. 6.2, Candidate Site Survey Planning.

5.1.6.3 Specify Establishment of Grid System

Refer to Sect. 6.3, Candidate Site Survey Planning.

5.1.6.4 Specify Radiation Measurements

For radiation measurements refer to Sect. 6.4, Candidate Site Survey Planning.

5.1.6.5 Determine Samples to be Collected

For samples to be collected, refer to Sect. 6.5, Candidate Site Survey Planning.

5.1.6.6 Determine Subcontract Services Requirement

Refer to Sect. 6.6, Candidate Site Survey Planning, for determining subcontract services requirements.

5.1.6.7 Determine Survey Schedule

Refer to Sect. 6.7, Candidate Site Survey Planning, for survey schedule requirements.

5.1.6.8 Prepare and Submit the Survey Plan

The site leader will prepare a vicinity properties radiological survey plan documenting the required activities for the survey. The plan should be submitted to the ORNL-RASA program manager for review and approval. The contents and format of a Vicinity Properties Survey Plan are presented in Sect. 10.5, Reports and Papers.

5.2 PREPARATION OF MOBILE SCANNING SURVEY PLAN

5.2.1 Purpose

The purpose of this procedure is to provide guidelines for the preparation of mobile gamma scanning survey plans.

5.2.2 Applicability

This procedure applies to the preparation of mobile gamma scanning survey plans by ORNL-RASA personnel.

5.2.3 References

1. Previous site aerial survey photographs, if any.
2. Previous mobile gamma scanning results, if any.

5.2.4 Definitions and Abbreviations

See Sect.1.5 of this manual, Terminology. 5.2.5 Responsibilities

5.2.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager has overall responsibility for the content and adequacy of the mobile gamma scanning survey plan. He will designate a site leader and reviewers for the plan and will be responsible for reviewing, transmitting, and coordinating the review of an submitting the plan for DOE approval.

5.2.5.2 Site Leader

The site leader is responsible for the preparation of the mobile gamma scanning survey plan. He will submit the plan into the review process; final approval is made by the ORNL-RASA program manager.

5.2.5.3 Reviewers

The reviewers will receive the mobile gamma scanning survey plan from the site leader and will review the plan to ensure that it is prepared according to the requirements of this procedure and that quality assurance and administrative requirements are satisfied. Review comments will be returned to the site leader within three days.

5.2.6 Procedure

5.2.6.1 Develop Mobile Scanning Survey Plan

Obtain, review, and assess information provided by previous aerial survey and mobile scan data, if available. Based on the available information, develop the survey plan following the steps below.

1. Define the scope or boundaries of the survey by outlining on a map of the general survey area (1) the areas of known contamination as indicated by the aerial survey results and (2) the extent of previous mobile gamma scans.
2. Using the outline established in the previous step (1), develop a street-by-street scanning plan for the area. Note from the aerial survey or previous mobile scan information, specific areas of high radiation levels that require special attention. This plan will normally identify the specific sections of town to be surveyed, or, if the entire city is to be scanned, define the outer limits of the survey.
3. With the results from the previous step (2), estimate the length of time required to complete the mobile gamma scan and develop a schedule for the survey. Provide a tentative date for start of the survey. This date is subject to the ORNL-RASA program manager's approval.
4. Prepare the survey plan for submittal to the ORNL-RASA program manager's review. The plan should include

   a. an introduction summarizing the information on the site obtained from previous aerial surveys and mobile scans, as applicable,
   b. the scope of the present planned survey, including (1) a ground level follow-up of the aerial survey and (2) the plan for the street-by-street mobile scan; when available, include a map showing the areas and boundaries of the proposed survey plan, and
   c. a schedule for the survey activities showing estimated survey start date, duration, end date, and date on which a report will be submitted to DOE.

5.2.6.2 Plan Submittal, Review, and Approval

The completed survey plan is submitted to the reviewers. Upon completion of the review, a final version of the plan is submitted to the ORNL-RASA program manager for final review and approval.

6. CANDIDATE SITE SURVEY PLANNING

SUBJECT: CANDIDATE SITE SURVEY PLANNING

6. CANDIDATE SITE SURVEY PLANNING

6.1 PREPARATION OF CANDIDATE SITE SURVEY PLAN

6.1.1 Purpose

The purpose of this procedure is to provide guidelines for preparing a Candidate Site Survey Plan.

6.1.2 Applicability

This procedure applies to the preparation of a survey plan for a candidate site by ORNL-RASA personnel. Refer to Sect. 6.2, Preparation for and Performance of Surveys.

6.1.3 References

1. Sect. 6.2, Preparation for and Performance of Surveys
2. Sect. 8.1, Identification and Planning of Support Functions
3. Sect. 10.5, Reports and Papers
4. Sect. 11.2, Specification of Measurement Grid System and Maps
5. Sect. 13.1, Background Measurements
6. Sect. 13.2, Alpha Radiation Measurements
7. Sect. 13.3, Beta-Gamma Radiation Measurements
8. Sect. 13.4, Transferable Alpha and Beta-Gamma Measurements
9. Sect. 13.5, Gamma Exposure Rate Measurements (Pressurized Ion Chamber)
10. Sect. 13.6, External Gamma Radiation Measurements
11. Sect. 13.7, Gamma Logging of Augered Holes
12. Sect. 13.9, Radon Measurements
13. Sect. 13.10, Measurement of Radon Daughter Activities in Air Samples
14. Sect. 13.11, Radon Flux Measurements
15. Sect. 14.1, Soil and Sediment Sample Collection
16. Sect. 14.2, Water Sample Collection
17. Sect. 14.3, Packaging and Shipment of Environmental Samples
18. Sect. 14.4, Sample Identification and Labeling
19. Sect. 14.5, Storage of Environmental Samples
20. Preliminary Site Survey Report

6.1.4 Definitions and Abbreviations

PIC. Pressurized Ion Chamber

Also see Sect. 1.5 of this manual, Terminology.

6.1.5 Responsibilities

6.1.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager has overall responsibility for the content and adequacy of the Candidate Site Survey Plan. He will designate a site leader and reviewers for the plan. He is also responsible for reviewing, transmitting, and coordinating the review of the plan and submitting it for DOE approval.

6.1.5.2 Site Leader

The site leader is responsible for the preparation of the Candidate Site Survey Plan according to the requirements of this procedure. He will submit the plan into the review process; final approval will be made by the ORNL-RASA program manager.

6.1.5.3 Reviewers

The reviewers will receive the Candidate Site Survey Plan from the site leader and review the plan to ensure that it is prepared according to the requirements of this procedure and that QA and administrative requirements are satisfied. Review comments will be returned to the site leader within three days.

6.1.6 Procedure

6.1.6.1 Review and Assess Preliminary Site Radiological Survey Report

The preliminary site radiological survey report should have been completed at this stage and should contain information relevant to the subsections to be discussed below. If additional information is required, the site leader should obtain it through proper channels.

Site usage history

Review the site usage history, paying special attention to the parameters that may indicate potential areas of contamination or that may affect radiation exposures to the public and workers. Examples of information that needs to be noted are:

1. Operations conducted at the site relevant to MED/AEC activities;
2. Methods and locations of processing, storage, and disposal of radioactive materials at the site;
3. Forms (gas, liquid, solid) of the radionuclides processed, stored, or disposed;
4. Radionuclides known or suspected to still be present at the site;

5. Areas and equipment that are, or may be, contaminated and occupancy of contaminated areas; and
6. Current condition, ownership, and legal property boundaries of the site.

Site geography and topography

Review the site geography and topography and note such features that may affect contaminated areas, radiological measurements or sampling, and radiation exposures to the workers or public. Special note should be made of possible means or sources of contamination of surrounding water bodies, vegetations, grazing land, etc.

Facility drawings/photographs

Review the facility drawings and photographs of previous processing and waste handling areas and locate potentially contaminated equipment and open areas. Note previous process and waste flows to and from the facility. Such information will facilitate planning and result in an effective survey program.

Present site usage

Review the current site usage and layout. Determine if current management has disturbed any of the site features since the last facility drawings were made.

Preliminary site survey results

Review results of the preliminary site radiological survey to determine locations of contaminated materials, types of contaminated materials, and any onsite support contractor requirements.

Aerial survey results

If an aerial survey has been made, obtain and review the results with particular emphasis on location(s) and intensity of abnormal radiation levels. These locations should be considered in developing the detailed survey plan.

6.1.6.2 Determine Potential Exposure Pathways

Based on the information obtained from preceding Sect. 6.1 subsections, identify the probable pathways (routes) by which the public may be exposed to radiation. The pathways may be one or more of the following:

1. Direct exposure to radiation,
2. Inhalation of radioactive particulates or gases (primarily radon and radon daughters), or
3. Ingestion of radioactivity through water or food.

The identification of the probable pathways will help to determine the measurements to be made and the samples to be collected.

6.1.6.3 Specify Establishment of Grid System

For a candidate site survey, a grid system is generally set up to facilitate identification of survey areas and sample locations. For details of establishing a grid system, see Sect. 11.2, Specification of Measurement Grid System and Maps. Once established, the grid system becomes the master location identification system for the site survey. All radiological measurements and sample locations are keyed to the location identification established by the grid system.

For criteria on determining sampling locations, refer to the sample collection procedure description in Sects. 3 and 11.2, Specification of Measurement Grid System and Maps.

6.1.6.4 Specify Radiation Measurements to be Made

Based on information obtained from Sects. 6.1 and 6.2, specify the radiological measurements to be made. Guides for specifying radiation measurements are given in the following subsections.

Background radiation

Determination of external gamma radiation levels in background areas should be specified to provide baseline data for comparison purposes. The measurement locations need not be specified in the plan because they will be determined in the field. Refer to Sect. 13.1, Background Measurements, for details of background radiation detection, instrumentation, and methods. It will also provide details for background sample collection.

External gamma-ray exposure rates

Provision should be made in the survey plan to measure and document external gamma-ray exposure rates to provide a radiation "map" to assist in planning and implementation of subsequent remedial action. These radiation measurements should be specified to include the following:

1. Exposure rate measurements at ground surface and one meter above ground at specified grid locations indoors and outdoors at the site; an average exposure rate for both indoors and outdoors can then be determined and maximum levels highlighted.
2. Surface gamma-ray scanning to define the areal extent of above-background radiation exposures.
3. Surface gamma-ray scanning of all equipment, building surfaces, and other materials at the site.
4. PIC measurements at locations of differing gamma radiation fields for cross correlation with gamma scintillation results.

Refer to Sect. 13.5, Gamma Exposure Rate Measurements (Pressurized Ion Chamber), and Sect. 13.6, External Gamma Radiation Measurements, for details of gamma-ray detection instrumentation and methods.

Beta-gamma dose rates

Beta-gamma dose rates should be specified for measurement and documentation of the following:

1. Specific locations where contamination by beta-emitting radionuclides is suspected.
2. Locations where gamma-ray exposure rates are significantly elevated.

Refer to Sect. 13.3, Beta-Gamma Radiation Measurements, for details of beta-gamma dose rate instrumentation and measurement techniques.

Direct surface alpha radiation

Indoor direct surface activities should be specified for measurement. The measurements should include the following:

1. Systematic measurement of surface alpha activity on walls and floor surfaces
2. Measurement of alpha activity at locations of elevated gamma or beta-gamma radiation levels
3. Measurement of alpha activity on selected equipment surfaces

Refer to Sect. 13.2, Alpha Radiation Measurements, for details of fixed alpha contamination measurement instrumentation and techniques.

Transferable beta-gamma and alpha activity on surfaces

Transferable beta-gamma and alpha activity on indoor surfaces should be specified for measurement. The measurements should include:

1. Random sampling of contamination levels throughout the structure;
2. Sampling at locations of suspect beta, alpha, and gamma contamination on walls and other indoor surfaces
3. Sampling of selected equipment surfaces

Refer to Sect. 13.4, Transferable Alpha and Beta-Gamma Measurements, for details of transferable activity measurement instrumentation and techniques.

Radon and radon daughter concentrations

At locations where the potential for indoor contamination of radon and radon daughters exists, measurements should be specified to determine:

1. Concentration of radon on each level of the structure to determine the instantaneous indoor concentration;
2. Concentration of radon in areas suspected of elevated concentrations (i.e., over drains, in poorly ventilated areas, etc.);
3. Concentrations of radon at locations where continuous measurements, see (4) of this list, or radon daughter sampling is being conducted, to provide for cross correlation;
4. Continuous radon concentration at selected locations within the structure to determine daily fluctuations and short-term average concentrations;
5. Radon daughter concentrations on each level of the structure to determine the instantaneous indoor concentrations; and
6. Radon daughter concentrations in areas with above-background radon concentrations or in areas suspected of containing elevated daughter levels.

Refer to Sect. 13.9, Radon Measurements, and Sect. 13.10, Measurement of Radon Daughter Activities in Air Samples, for details of radon and radon daughter measurement instrumentation and techniques.

Surface radon flux measurements

Where there is a potential for radon infiltration into structures, surface radon flux measurements can be specified to determine the radon source (i.e., drain, floor cracks, etc.) and provide an estimate of the flux at the measurement location.

Refer to Sect. 13.11, Radon Flux Measurements, for details of measurement instrumentation and techniques.

Subsurface gamma-ray logging of auger holes

Where indoor or outdoor drilling is specified (see Sect. 6.6), subsurface gamma-ray logging of auger holes should also be specified to provide:

1. An indication of gross radiation levels as a function of depth which will provide the information about the interface between clean and contaminated soils, and the depth and thickness of clean and contaminated soils, and
2. Correlation of gamma radiation levels with subsurface soil sample radionuclide analyses.

Refer to Sect. 13.7, Gamma Logging of Augered Holes, for details of gamma logging instrumentation and methods.

Air particulate concentrations

If conditions at the site result in significant airborne dust, determination of radionuclide concentrations in air at the locations where these conditions exist should be specified. The measurements should provide for:

1. Quantification of gross alpha and gross beta-gamma activity per unit of air volume;
2. Half-life of short-lived primary contaminants; and
3. Identification of long-lived radionuclides of concern.

Others

If there are other parameters that need to be measured, they should also be indicated in the plan in sufficient detail for field operation to proceed.

6.1.6.5 Determine Samples to be Taken

Based on information obtained in Sects. 6.1, 6.2, and 6.4, specify the environmental samples to be taken.

Sampling locations will be documented according to the grid system referenced in Sect. 6.3.

Background samples

For all types of samples specified to be taken (i.e., water, surface, and subsurface soil, etc.) a background sample will also be obtained and analyzed to provide the baseline data for comparison purposes. Locations for background samples will be determined at the site. For guidelines on background sample collection, refer to Sect. 13.1, Background Measurements.

Soil samples

Surface and subsurface soil sampling should be identified in the plan according to the following:

1. A composite outdoor surface soil sample or a series of systematic or random soil samples should be obtained and analyzed to determine average surface soil radionuclide concentrations.
2. Biased samples should be obtained at locations showing elevated radiation levels and from locations of known soil contamination.
3. Subsurface soil samples should be taken from all drill holes; samples should be taken from the sides of the holes or as a continuous core; the results of analyses will indicate the total thickness and depth of contamination.

Refer to Sect. 13.1, Background Measurements, and Sect. 14.1, Soil and Sediment Sample Collection, for more details of soil sample collection and techniques.

Water samples

Water samples from the site and surrounding area should be obtained and analyzed. Depending on the site, water sources may be rivers, streams, lakes, potable water, wells, etc. Water found in any drill hole should be sampled and submitted for analysis. Refer to Sect. 14.2, Water Sample Collection, for details of water sample collection methods.

Water sediment

A sediment sample should be specified to be obtained from each location where surface water is to be taken. Refer to Sect. 14.1, Soil and Sediment Sample Collection, for details on sediment sample collection methods.

Vegetation

Although vegetation is not routinely being obtained for analysis, collection of such samples should be specified when the potential for food chain exposure justifies it. For example, if a vegetable garden has been planted over contaminated soil, vegetable samples should be obtained and analyzed.

Others

If there are other materials suspected of being contaminated (i.e., building supplies, rocks, filters, etc.), sampling should be specified in the plan.

6.1.6.6 Determine Subcontract Services Requirement

Based on the requirements established for sampling, radiation measurements, and the conditions of the site, requirements for subcontract services not available within ORNL should be specified.

The subcontract services may include:

1. Industrial cleaners - for clearing and cleaning buildings before indoor survey;
2. Landscape maintenance - for clearing vegetation and rubble before survey;
3. Land surveyors - for establishing property lines, base maps, and layout of the grid system;
4. Construction contractors - for earth and large debris removal (i.e., backhoe, tractor, front-end loader, etc.) to provide access to areas to be surveyed;
5. Drill and auger contractors - for drilling services for subsurface sampling, including augering and continuous core sampling;
6. Soil sample processors - for soil and sediment sample preparation for onsite analysis; and
7. Technical services - for providing services such as health physics, or other technical personnel or services that cannot be provided by ORNL.

The subcontract services will be obtained according to the requirements of the procedure of Sect. 8.1, Identification and Planning of Support Functions.

6.1.6.7 Determine Survey Schedule

Provide a tentative floating schedule for completion of the survey activities. The schedule should indicate specific activities, the duration of work for each activity, and the manpower requirements for each activity. The schedule should emphasize the duration of the survey rather than the calendar schedule because many outside factors will affect the calendar schedule.

6.1.6.8 Prepare and Submit the Radiological Survey Plan for Review and Approval

The plan should be prepared in accordance with the procedure of Sect. 10.5, Reports and Papers, and submitted to the reviewers for the review process. Upon completion of the review and revision, the final document will be submitted to the ORNL-RASA program manager for final review and approval.

6.2 PREPARATION FOR AND PERFORMANCE OF SURVEYS

6.2.1 Purpose

The purpose of this procedure is to provide guidelines for the preparation for and performance of radiological surveys at remote sites.

6.2.2 Applicability

This procedure applies to the preparation for and performance of preliminary site surveys, comprehensive candidate site surveys, vicinity properties surveys, and postremedial action surveys.

6.2.3 References

1. Sect. 8.1, Identification and Planning of Support Functions
2. Sect. 10.3, Data Storage
3. Sect. 16.1, Mobile Laboratory Equipment Inventory
4. Sect. 18.1, Procurement of Services and Equipment
5. Sect. 19.2, Indoctrination, Training and Qualification of Personnel
6. Preliminary site survey plan (as applicable)
7. Candidate site survey plan (as applicable)
8. Vicinity properties survey plan (as applicable)
9. Postremedial action survey plan (as applicable)

6.2.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

6.2.5 Responsibilities

6.2.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for the performance of radiological surveys.

6.2.5.2 Site Leader

The site leader or his designee is responsible for all the radiological survey activities called for in the plan. He is responsible for the preparation for and performance of the survey activities.

6.2.6 Procedure

6.2.6.1 Review Radiological Survey Plan

Review the radiological survey plan prepared previously and any site-related information that may have become available following plan preparation. Based on the plan requirements, prepare for the actual survey.

6.2.6.2 Survey Preparation

Determine subcontract services requirements

From the survey plan, determine requirements for subcontract services. If necessary, prepare specifications for the subcontract services for input to the request for proposal or contract for these services. For details see Sect. 8.1, Identification and Planning of Support Functions, and Sect. 18.1, Procurement of Services and Equipment.

Monitor the progress and status of obtaining the subcontract services to ensure that such services will be available to support the survey schedule and activities. If problems arise, the ORNL-RASA program manager should be so advised.

Determine also the contacts for the various utilities (gas, water, telephone, electricity, etc.) to make sure that their services will be available when needed.

Determine survey requirements

From the survey plan, determine the activities which will be performed at the site. Divide the survey plan into activities adequately covered by an operational procedure and check off the applicable procedures on Exhibit 6.1.

Assign survey team members

From the survey requirements indicated above, determine the personnel requirements for the team. Based on these requirements, organize a tentative survey team considering the available group resources. Present the team to the ORNL-RASA program manager for tentative approval. Once approved, advise the team members of their assignments and determine if conflicts exist. Such conflicts must be satisfactorily resolved before the team can be considered organized.

Prepare survey equipment and supplies

Within one week of the survey trip, the site leader, assisted by his survey team, should check and ensure that the survey equipment, tools, and supplies are on hand and ready for use. Exhibit 6.1 in which only procedure numbers are indicated, should be cross-checked with the inventory sheet for the mobile laboratory (Sect. 16.1, Mobile Laboratory Equipment Inventory). After the equipment, tools, and supplies are determined to be on board, the team should check them for proper operation.

Prepare Field Data Log Book for documenting site measurements and activities. For details, refer to Sect. 10.3, Data Storage.

Ensure site owner notification

One week before the survey trip, the site leader will ensure that the site or property owner(s) has been notified of the planned survey, by confirming the visit by telephone. If problems exist, notify the ORNL-RASA program manager.

Prepare travel arrangements and itinerary

As far ahead as practical, make hotel and car reservations for the team members. One week before the trip, prepare an itinerary for distribution to the team members and the office manager. At this time, reconfirm team members' availability for the trip. One day before the trip, check the weather forecast for the site and transmit information of interest to the team members.

New personnel training

All members of the survey team who are newly assigned to ORNL-RASA must be trained according to the procedure of Sect. 19.2, Indoctrination, Training, and Qualification of Personnel, before performing survey activities.

Prepare survey vehicle

Check with the Mobile Lab Coordinator to ensure that the survey vehicle is ready for the trip. These checks are similar to safety checks on a personal automobile. The list is shown in Exhibit 6.2. The above checks are performed in addition to regular vehicle repair and maintenance provided by the ORNL garage. If any defects or unsafe conditions are discovered prior to a trip, they should be corrected by the garage as soon as possible. Any unsafe conditions observed during a trip should be corrected as soon as possible in the field or after the trip to make the vehicle ready for the next trip.

6.2.6.3 Survey Performance

The radiological survey is performed according to the individual procedures for each activity specified in the plan. Each procedure should provide the necessary requirements for that particular activity.

6.2.6.4 Data Collection

All data generated from the site survey activities are logged into the Field Data Log Book by the site leader. The data will be used in preparing the site survey report. For details, refer to Sect. 10.3, Data Storage.

SUBJECT: CANDIDATE SITE SURVEY PLANNING

Exhibit 6.1. Form for survey supplies and equipment check.

Date: Site leader:

Site:

Survey type: _____Candidate site
_____Vicinity properties
_____Post remedial action
_____preliminary site

Operational procedures For the survey (check all applicable)		Supplies & equipment on board (cross-checked mobile laboratory inventory)	Supplies & equipment in working order
13.1	_____	_____	_____
13.2	_____	_____	_____
13.3	_____	_____	_____
13.4	_____	_____	_____
13.5	_____	_____	_____
13.6	_____	_____	_____
13.7	_____	_____	_____
13.8	_____	_____	_____
13.9	_____	_____	_____
13.10	_____	_____	_____
13.11	_____	_____	_____
13.12	_____	_____	_____
13.13	_____	_____	_____
14.1	_____	_____	_____
14.2	_____	_____	_____
14.3	_____	_____	_____
14.4	_____	_____	_____
14.5	_____	_____	_____
14.6	_____	_____	_____
14.7	_____	_____	_____
14.8	_____	_____	_____
14.9	_____	_____	_____
17.1	_____	_____	_____
17.2	_____	_____	_____
17.3	_____	_____	_____
17.4	_____	_____	_____

Exhibit 6.2. Form for survey vehicle check.

			Normal
Tire pressure, front		____PSI	____PSI
Tire pressure, rear		____PSI	____PSI
Spare tire pressure		____PSI	____PSI
Engine oil level		_____	Full
Radiator water level		_____	Full
Fuel level		_____	Full
Wiper fluid level		_____	Full
Battery water level		_____	Good
Windshield wipers		_____	Work
Headlights		_____	Work
Brake lights		_____	Work
Stop lights		_____	Work
Horns		_____	Work
First aid kit	____Yes	____No	Yes
Jack	____Yes	____No	Yes
Lug wrench	____Yes	____No	Yes
Screw driver	____Yes	____No	Yes
Quart, motor oil	____Yes	____No	Yes
Tire pump	____Yes	____No	Yes
Tire gauge	____Yes	____No	Yes

7. POSTREMEDIAL ACTION SURVEY PLANNING

SUBJECT: POSTREMEDIAL ACTION SURVEY PLANNING

7. POSTREMEDIAL ACTION SURVEY PLANNING

7.1 PREPARATION OF POSTREMEDIAL ACTION SURVEY PLAN

7.1.1 Purpose

The purpose of this procedure is to provide guidelines for preparing postremedial action survey plans. At the present time, the details of such a survey have not been defined. This procedure, therefore, discusses the plan in a general manner.

7.1.2 Applicability

This procedure applies to the preparation of postremedial action survey plans by ORNL-RASA personnel. The postremedial action surveys include post-restoration surveys. For the preparation for and performance of surveys refer to Sect. 6.2, Preparation for and Performance of Surveys.

7.1.3 References

1. Sect. 6.1, Preparation of Candidate Site Survey Plan
2. Sect. 6.2, Preparation for and Performance of Surveys

7.1.4 Definitions and Abbreviations

7.1.4.1 Definitions

REMEDIAL ACTION. Any activity performed to reduce the radiocontamination at a site for the purpose of achieving the objectives indicated in the remedial action plan.

SITE. Any facility or location being surveyed. It may be a candidate site or a vicinity property.

REVIEWERS. Any person designated by the ORNL-RASA program manager to review a radiological survey plan.

Also see Sect. 1.5 of this manual, Terminology.

7.1.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

7.1.5 Responsibilities

7.1.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager has overall responsibility for the postremedial action survey plan. He will designate a site leader and reviewers for the preparation of the plan. He is also responsible for reviewing, transmitting, and coordinating the review and final approval of the plan and submitting it to DOE for approval.

7.1.5.2 Site Leader

The site leader is responsible for preparing the postremedial action survey plan. He will submit the plan into the review process, resolve comments, and submit the plan to the ORNL-RASA program manager for approval.

7.1.5.3 Reviewers

The reviewers will receive the postremedial action survey plan from the site leader and will review the plan to assure that operational, quality assurance, and administrative requirements are satisfied. Review comments will be returned to the site leader within three days of plan receipt.

7.1.6 Procedure

NOTE: Postremedial action surveys are performed to verify that the remedial actions undertaken by other organizations have successfully achieved the objectives stated in the remedial action plan. Because the remedial actions are known, it is generally only necessary to verify the results of these remedial actions. Surveys may be performed and samples collected at the discretion of the site leader.

1. Obtain a copy of the remedial action plan and note the objectives of the plan, especially the applicable guidelines set forth by the governing regulatory agency.
2. Identify the remedial actions to be undertaken and relate these actions to specific equipment, areas, radiation levels, etc.
3. Prepare a plan to verify the results of the remedial action. The plan should include all the necessary radiation measurements and samplings to the objectives of the remedial action plan.

As applicable, follow Sects. 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, and 6.8 in Sect. 6, Candidate Site Survey Planning.

7.1.6.1 Submit Survey Plan for Review and Approval

Upon completion of the plan, submit it into the review process, resolve comments, and submit to ORNL-RASA program manager for approval.

8. SUPPORT FUNCTION PLANNING

SUBJECT: SUPPORT FUNCTION PLANNING

8. SUPPORT FUNCTION PLANNING

8.1 IDENTIFICATION AND PLANNING OF SUPPORT FUNCTIONS

8.1.1 Purpose

The purpose of this procedure is to provide guidance for planning of the survey site support functions for each survey plan.

8.1.2 Applicability

This procedure applies to all planning for subcontractor support function activities at the survey site in support of the ORNL-RASA program.

8.1.3 References

1. Sect. 4, Preliminary Survey Planning
2. Sect. 5, Vicinity Properties Survey Planning
3. Sect. 6, Candidate Site Survey Planning
4. Sect. 7, Postremedial Action Survey Planning
5. Sect. 11, Pre-Survey Activities
6. Sect. 11.3, Identification of Subcontractor Requirements
7. Sect. 18, Subcontract Services and Administration

8.1.4 Definitions and Abbreviations

8.1.4.1 Definitions

SUBCONTRACTOR. A manufacturer or organization that receives a contract from a prime contractor for a portion of the work on the project. For purposes of this procedure, the prime contractor is Martin Marietta Energy Systems, Inc.

Also see Sect. 1.5 of this manual, Terminology.

8.1.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

8.1.5 Responsibilities

The site leader is responsible for implementation of this procedure.

SUBJECT: SUPPORT FUNCTION PLANNING

8.1.6 Procedure

8.1.6.1 Site Leader

The site leader will prepare and integrate this procedure into his survey plan. Refer to survey planning procedures in Sects. 4, 5, 6, and 7 of this Procedures Manual. For these survey plans, he determines which subcontractor services he shall require from the following:

1. Industrial cleaners - used for clearing and cleaning building prior to indoor survey;
2. Landscape maintenance - used for clearing vegetation and rubble before the outdoor survey;
3. Surveyors - establishment of measurement grid system, property lines, and preparing base maps;
4. Construction contractors - used for earth and large debris removal (i.e., backhoe, caterpillar, front-end loader, etc.) for personnel access for surveys;
5. Drilling and auger contractors - provide drilling services for subsurface sampling, including augering and continuous core sampling; and
6. Technical support - used for obtaining technicians and professional radiological health personnel for support in the radiological survey.

8.1.6.2 Identification of Required Procedures

Based on the needs determined by the site leader in accord with Sect. 6.1 of this procedure, the applicable survey plan shall then address the individual contractor functions to identify the pre-survey planning and implementing procedures of Sect. 11 that are required. Following DOE approval of the survey and after completion of the procedure of Sect. 11.3, Identification of Subcontractor Requirements, the survey plan will call for implementation of procedures in Sect. 18.1, Procurement of Services and Equipment; Sect. 18.2, Administration of Subcontracts; and Sect. 18.3, Subcontractor Reporting, for each subcontractor. At least one month lead time must be allowed between the time the subcontract requirements are submitted to Martin Marietta Energy Systems, Inc. Procurement and the time frame needed for subcontractor work implementation.

8.1.6.3 Wage Scale Information

The ORNL-RASA program manager is responsible for submitting a request to Martin Marietta Energy Systems, Inc. Procurement to obtain an annual report of the wage scales in parts of the country where survey work is expected to be accomplished.

9. QA PLANNING

SUBJECT: QA PLANNING

9. QA PLANNING

9.1 QA PLANNING

9.1.1 Purpose

The purpose of this procedure is to describe the integration of QA requirements into the planning and performance of site survey activities.

9.1.2 Applicability

This procedure applies to all activities of the ORNL-RASA program.

9.1.3 References

1. Sect. 4.1, Preliminary Survey Planning
2. Sect. 5.1, Preparation of Vicinity Properties Survey Plan
3. Sect. 6.1, Preparation of Candidate Site Survey Plan
4. Sect. 6.2, Preparation for and Performance of Surveys
5. Sect. 7.1, Preparation of Postremedial Action Survey Plan
6. Sect. 8.1, Identification and Planning of Support Functions
7. Sect. 19, QA Procedures

9.1.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

9.1.5 Responsibilities

9.1.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager has overall responsibility for QA planning and is assisted by the QA coordinator.

9.1.5.2 QA Coordinator

The QA coordinator is responsible for reviewing and monitoring all plans and activities developed in accordance with referenced procedures identified in Sect. 3 of this procedure to ensure that adequate QA aspects have been considered.

9.1.5.3 Site Leader

The site leader is responsible for incorporating the requirements of this procedure and Sect. 19, QA Procedures, in all planning activities developed in accordance with referenced procedures identified in Sect. 3 of this procedure.

9.1.6 Procedure

NOTE: Each of the following subsection titles also identifies the titles of QA procedures as discussed in the text of the subsection.

9.1.6.1 Interface Control

During planning activities, the site leader should familiarize himself with the requirements of the procedure of Sect. 19.1, Interface Control, to ensure that all personnel selected for site survey teams are fully informed of their responsibilities and limitations with respect to contacting outside organizations.

9.1.6.2 Indoctrination, Training, and Qualification of Personnel

As part of the selection of site survey team members, the site leader should obtain information with respect to qualifications of individuals from the ORNL-RASA program manager, identify the requirements for additional training of individuals, where applicable, and schedule survey team indoctrination sessions to ensure that information pertinent to site survey requirements is fully understood by all survey team members. See Sect. 19.2 of this manual, Indoctrination, Training, and Qualification of Personnel, for further guidance.

9.1.6.3 Control of Purchased Items and Services

In accordance with the procedure of Sect. 19.6 of this manual, Control of Purchased Items and Services, the ORNL-RASA program manager, assisted by the QA Coordinator, will ensure that requirements for the control of purchased items and services are adequately incorporated in procurement activities associated with site surveys. This will be accomplished by review of requests for purchase generated by the site leader and is directly dependent upon established ORNL standard practices and guidelines for procurement.

9.1.6.4 Identification and Control of Material and Equipment

The site leader shall ensure, during the planning stages of the site survey, that equipment and material to be used during the performance of site survey activities are available, authorized for use, and properly identified in accordance with the procedure of Sect. 19.7, Identification and Control of Material and Equipment.

9.1.6.5 Inspection, Test, and Operating Status

The status of site survey activities as reflected in logs and other data and reported in periodic status reports is described in Sect. 19.8, Inspection, Test, and Operating Status. The same procedure contains requirements for the checking of equipment and instrumentation used during site survey activities to ensure their continued good condition and operability.

9.1.6.6 Sample Collection, Control, and Documentation

Detailed requirements for sample collection, shipping, handling, receiving, analyses, and documentation are described in applicable implementing procedures of this manual. However, these requirements are generally referenced or reiterated in Sect. 19.9, Sample Collection, Control, and Documentation, for the purpose of emphasizing their importance. The QA coordinator will review site survey planning activities and pay particular attention to integration of quality requirements associated with radiological/environmental samples and measurements.

9.1.6.7 Project Document Control

To insure that instructions, procedures, drawings, and other site survey-related data are available in the latest revision and used at the site, the procedures of Sect. 19.11, Project Document Control, provides a method by which this may be accomplished. The site leader shall continually assess the status of critical data used as input for site survey activities to ensure their applicability. ORNL-RASA procedures will be distributed as a manual only to ensure that referenced procedures are at hand for personnel required to follow the procedures.

9.1.6.8 Calibrations and Intercomparison Data

As an additional check on the quality of calibration of equipment and instrumentation used in site survey activities, Sect. 19.12, Calibrations and Intercomparison Data, provides for the periodic analyses of quality samples through EPA and NRC programs designed to detect errors in sample analyses. The QA coordinator will develop plans and reports concerning this program as necessary.

9.1.6.9 Control of Deficient Items

Limited to deficiencies related to equipment and instrumentation, the procedures of Sect. 19.13, Control of Deficient Items, provides requirements for identification, temporary disposition, methods of repair or modification and reporting of deficiencies. Methods are provided to isolate those activities conducted utilizing deficient equipment so that either the activities are repeated or an evaluation of their acceptability is made.

9.1.6.10 Maintenance and Control of Records and Data

The control of records is a major aspect of any quality program and should be appreciated for its significance as documentation that an activity has been performed. Therefore, to provide for retrievability of records of ORNL-RASA activities, Sect. 19.15, Maintenance and Control of Records and Data, contains requirements for indexing, filing, and maintenance of records and data. These requirements are integrated into ORNL-RASA planning and performance activities by virtue of the fact that all completed records and data are transmitted by the records technician to designated files, which are the responsibility of the QA coordinator.

9.1.6.11 Surveillance Program

The requirements for a surveillance program as described in Sect. 19.16, Surveillance Program, apply to the level of compliance to ORNL-RASA procedures. Essentially, this is achieved through the continuous monitoring and surveillance of ORNL-RASA activities by all members of the ORNL-RASA staff. However, provisions exist within each specific implementing procedure for the identification of adverse trends and corresponding actions to be taken to correct them.

10. PROJECT MANAGEMENT

10. PROJECT MANAGEMENT

10.1 PROJECT ORGANIZATION AND SCHEDULING

10.1.1 Purpose

The purpose of this procedure is to provide guidelines for project organization and scheduling.

10.1.2 Applicability

This procedure applies to all radiological survey projects conducted by ORNL-RASA in support of the DOE-RASA program.

10.1.3 References

None.

10.1.4 Definitions and Abbreviations

10.1.4.1 Definitions

PROJECT. All activities associated with an individual candidate site, including vicinity properties associated with the site.

Also see Sect. 1.5 of this manual, Terminology.

10.1.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

10.1.5 Responsibilities

10.1.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for the implementation of this procedure. He will further be responsible for the overall scheduling of all ORNL-RASA program projects within the guidelines and directives for scheduling provided by DOE.

10.1.5.2 Site Leader

The site leader is responsible for the scheduling of all aspects of the assigned project, subject to approval by the ORNL-RASA program manager.

10.1.6 Procedure

10.1.6.1 Project Organization

Elements of the project organization include:

1. ORNL-RASA program manager
2. Site leader
3. Survey team members
4. Laboratory support staff
5. Clerical support staff

The project organization is illustrated in Project Organization (Exhibit 10.1).

The ORNL-RASA program manager assigns a site leader to each project, although a single individual may be assigned as site leader for more than one project.

Only the site leader has a unique identification with a particular project. Other scientific or support staff may be assigned to a project only for the duration of a particular survey or activity. Survey team members will be assigned to the project for a particular survey that may range in duration from a two-day initial site visit to several week-long radiological surveys at a large site.

Certain laboratory support staff members may be responsible for certain laboratory, instrumentation, or data analysis resources of the group. When these personnel are assigned to a project for a particular survey, there is also the implication of the commitment of the hardware resources for which that person is responsible.

Clerical support functions such as report typing and documentation are normally a group function and not assigned to a particular project. The support staff may be supporting several projects at any given time.

10.1.6.2 Project Scheduling

ORNL-RASA program manager

DOE sets the priorities for projects in many instances. Where DOE has not set a priority, the ORNL-RASA program manager sets project priority, with the approval of DOE. Following the determination of project priority, the ORNL-RASA program manager develops a schedule for all ORNL-RASA projects consistent with their available time, funds, and resources.

Site leader

The site leader has the overall responsibility for project scheduling, within the constraints imposed by the overall schedule of projects developed by the ORNL-RASA program manager.

SUBJECT: PROJECT MANAGEMENT

In preparing a project schedule, the site leader must determine the following factors:

1. Type of survey(s) required
2. Site size
3. Site complexity
4. Available manpower resources
5. Available equipment resources
6. Subcontractor requirements
7. Travel time/distance from ORNL

Following the determination of these factors, the site leader must interface with the ORNL-RASA program manager and other site leaders to determine manpower and equipment resources available to his project. The scheduling of subcontractors is then integrated into the overall schedule when necessary to provide:

1. Timely subcontractor action consistent with the schedule,
2. Minimal interference between subcontractor and survey team, and
3. Survey team on site when necessary to overview subcontractor activities.

10.2 PROJECT RECORDKEEPING

10.2.1 Purpose

The purpose of this procedure is to describe the format and content of records generated by radiological surveys as conducted by ORNL-RASA program personnel.

10.2.2 Applicability

This procedure applies to all ORNL-RASA program projects.

10.2.3 References

1. Sect. 11.1, Evaluation of Site Records and Data
2. Sect. 12.1, Mobile Gamma Scanning Van Operation
3. Sect. 13.1, Background Measurements
4. Sect. 13.2, Alpha Radiation Measurements
5. Sect. 13.3, Beta-Gamma Radiation Measurements
6. Sect. 13.4, Transferable Alpha and Beta-Gamma Measurements
7. Sect. 13.5, Gamma Exposure Rate Measurements (Pressurized Ion Chamber)
8. Sect. 13.6, External Gamma Radiation Measurements
9. Sect. 13.7, Gamma Logging of Augered Holes
10. Sect. 13.8, Onsite Gamma Spectrometry
11. Sect. 13.9, Radon Measurements

12. Sect. 13.10, Measurement of Radon Daughter Activities in Air Samples
13. Sect. 13.13, Field Photography
14. Sect. 14.9, Storage of Environmental Samples
15. Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples
16. Sect. 15.3, Determination of Radionuclides in Water Samples
17. Sect. 15.8, Soil and Sediment Sample Preparation
18. Sect. 19.15, Maintenance and Control of Records and Data
19. Sect. 20.1, Calibration of Alpha Scintillators
20. Sect. 20.2, Calibration of Gas Flow Proportional Alpha Counters
21. Sect. 20.3, Calibration of Alpha Smear Counters
22. Sect. 20.4, Calibration of Alpha Spectrometry Systems
23. Sect. 20.5, Calibration of Geiger-Mueller Survey Meters
24. Sect. 20.7, Calibration of Beta-Gamma Pancake Counters
25. Sect. 20.8, Calibration of Beta-Gamma Smear Counters
26. Sect. 20.10, Calibration of Portable Gamma Scintillation Detectors
27. Sect. 20.11, Calibration of Portable Gamma Spectrometry Systems
28. Sect. 20.14, Calibration of Gamma Hole-Logging Equipment
29. Sect. 20.15, Calibration of Wrenn Chambers
30. Sect. 20.16, Calibration of Lucas and ORNL Cells
31. Sect. 20.18, Calibration of Air Pumps
32. Sect. 20.19, Calibration of Mass Scales

10.2.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

10.2.5 Responsibilities

10.2.5.1 Site Leader

The site leader is responsible for the implementation of this procedure.

10.2.5.2 Records Technologist

The records technologist is responsible for records maintenance, retention, and retrieval in accordance with the procedure of Sect. 19.15, Maintenance and Control of Records and Data.

10.2.5.3 All Personnel

All personnel required to enter data into records are responsible for data entry in conformance with this procedure.

10.2.6 Procedure

10.2.6.1 Records Format and Requirements

Records format

The format used for all ORNL-RASA records shall be free form, generally following the accepted and common practices of ORNL-RASA for each specific record document.

Records requirements

All data, notes, measurements, and calibrations pertinent to a candidate site or vicinity properties must be recorded or entered into the appropriate project record. All recorded entries into records documents will, without exception, conform to the following requirements:

1. All entries will be marked with the date of entry;
2. All entries will be signed or marked with a sign (initials, etc.) traceable, without ambiguity, to the author of the entry;
3. All entries will be written or printed in an easily legible manner; and
4. All entries will be concise and exact, accurately describing the observation, event, or measurement to be documented.

10.2.6.2 Project Record Types

Project records consist of a series of files, log books, and documents, including

1. Field Data Log Book
2. Radon Data Log Book
3. Scanning Van Calibration Log Book
4. Scanning Van Log Book
5. Alpha Smear Counter Log Book
6. Beta-Gamma Smear Counter Log Book
7. Na(I) Detector Log Book
8. Alpha Spectrometer Log Book
9. Portable Instrument Log Book
10. Drill Hole Logger Log Book
11. Radon Log Book (Lucas and ORNL Cells)
12. Instrument Calibration Log Book
13. Soil Sample Preparation Log Book
14. Air Pump and Mass Flow Meter Calibration Log Book
15. Wrenn Chamber Calibration Log Book
16. ORNL-LUCAS Cell Calibration Log Book
17. Soil Sample Data Log Book
18. Water Sample Data Log Book

19. Soil Counter Tape (MAG Tape) Log Book
20. Soil Counter Tape (DEC Tape) Log Book
21. ND System Sample Counting Log Book
22. 5/11 System Sample Counting Log Book
23. Project File
24. U.S. Soil Sample Background Record Book
25. Sample Archives
26. Published Reports

Field Data Log Book

The Field Data Log Book is the primary repository for all measurements, data, and samples taken at the site. This log book is the site leader's notebook and diary in which all information necessary to document the radiological survey is recorded; it assists the site leader in writing the survey report.

There may be several volumes of log books for a site due either to the amount of information that is recorded or because it is sometimes convenient to have more than one log book available to the several survey members who are participating in the survey.

All field survey data are recorded in this log book. Content requirements are included in the appropriate procedure for each type of data entry.

The log book serves also as a diary of the day's activity. Necessary information that should be recorded in the log book includes

1. Notations on weather conditions,
2. Notation or indication of the location of all work,
3. At the end of each day, notations of what occurred that day, and
4. Documentation of all official contacts with property owners, local officials, media representatives, remedial action contractors, etc.

Radon Data Log Book

All site radon and radon daughter measurement results are recorded in this log book. Content requirements for Radon and Radon Daughter Log Book entries are included in Sects. 13.9, Radon Measurements, and 13.10, Measurement of Radon Daughter Activities in Air Samples.

Scanning Van Calibration Log Book

All daily calibration data are recorded in this log book. Content requirements for log book entries are included in Sect. 12.1, Mobile Gamma Scanning Van Operation.

Scanning Van Log Book

All scan survey results are recorded in this log book. Content requirements for Scanning Van Log Book entries are included in Sect. 12.1, Mobile Gamma Scanning Van Operation.

Alpha Smear Counter Log Book

Each alpha smear counter has its own dedicated log book. This log book contains all information pertinent to alpha smear counter calibration (data and factors) and operational notes. Operational notes include instrument control settings, repairs, adjustments, and observed anomalies in operation. Sample measurement data are entered into the Field Data Log Book. Content requirements for the Alpha Smear Counter Log Books are included in Sects. 13.4, Transferable Alpha and Beta-Gamma Measurements, and 20.3, Calibration of Alpha Smear Counters.

Beta-Gamma Smear Counter Log Book

Each beta-gamma smear counter has its own dedicated log book. This log book contains all information pertinent to beta smear counter calibration (data and factors) and operational notes. Operational notes include instrument control settings, repairs, adjustments, and observed anomalies in operation. Sample measurement data are entered into the Field Data Log Book. Content requirements for the Beta-Gamma Smear Counter Log Books are included in Sects. 13.4, Transferable Alpha and Beta-Gamma Measurements, and 20.8, Calibration of Beta-Gamma Smear Counters.

Na(I) Detector Log Book

Each Na(I) detector has its own dedicated log book. This log book contains all information pertinent to gamma spectrometry Na(I) system calibration (data and factors) and operational notes. Operational notes include instrument control settings, repairs, adjustments, and observed anomalies in operation. Content requirements for the Na(I) Detector Log Books are included in Sects. 13.8, Onsite Gamma Spectrometry, and 20.11, Calibration of Portable Gamma Spectrometry Systems.

Alpha Spectrometer Log Book

Each alpha spectrometer has its own dedicated log book. This log book contains all information pertinent to alpha spectrometer calibration (data and factors) and operational notes. Operational notes include instrument control settings, repairs, adjustments, and observed anomalies in operation. Sample measurement data are entered into the Field Data Log Book. Content requirements for the Alpha Spectrometer Log Books are included in Sect. 20.4, Calibration of Alpha Spectrometry Systems.

Portable Instrument Log Book

Each mobile laboratory is equipped with a Portable Instrument Log Book. This log book contains all information pertinent to portable survey meter calibration (data and factors) and operational notes. Operational notes

include instrument control settings, repairs, adjustments and observed anomalies in operation. Sample measurement data are entered into the Field Data Log Book. Content requirements for the Portable Instrument Log Book are included in the following sections of this manual for each appropriate instrument:

1. Sect. 13.1, Background Measurements
2. Sect. 13.2, Alpha Radiation Measurements
3. Sect. 13.3, Beta-Gamma Radiation Measurements
4. Sect. 13.5, Gamma Exposure Rate Measurements (Pressurized Ion Chamber)
5. Sect. 20.1, Calibration of Alpha Scintillators
6. Sect. 20.2, Calibration of Gas Flow Proportional Alpha Counters
7. Sect. 20.5, Calibration of Geiger-Mueller Survey Meters
8. Sect. 20.7, Calibration of Beta-Gamma Pancake Counters
9. Sect. 20.10, Calibration of Portable Gamma Scintillation Detectors

Drill Hole Logger Log Book

Each mobile laboratory is equipped with a Drill Hole Logger Log Book. This log book contains all information pertinent to the Drill Hole Logger, including calibration (data and factors) and operational notes. Operational notes include instrument control settings, repairs, adjustments, and observed anomalies in operation. Sample measurement data are entered into the Field Data Log Book. Content requirements for the Drill Hole Logger Log Book are included in Sects. 13.7, Gamma Logging of Augered Holes, and 20.14, Calibration of Gamma Hole-Logging Equipment.

Radon Cell Log Book

Each mobile laboratory is equipped with a Radon Cell Log Book (for ORNL Cell and Lucas Cell information). This log book contains all information pertinent to ORNL and Lucas Cell counting system calibration (data and factors) and operational notes. Operational notes include instrument control settings, repairs, adjustments, and observed anomalies in operation. Sample measurement data are entered into the Field Data Log Book. Content requirements for the ORNL and Lucas Cell Counting system are included in Sects. 13.9, Radon Measurements, and 20.16, Calibration of Lucas and ORNL Cells.

Instrument Calibration Log Book

The ORNL-RASA laboratory contains the Instrument Calibration Log Book. This log book contains all information pertinent to gamma scintillator, Geiger-Mueller survey meter, alpha scintillator, gas flow alpha meter and mass-scale calibration data, and operational notes. Calibration values determined by the appropriate ORNL calibration facility are recorded in this log book. Operational notes include control settings, where applicable, repairs, adjustments or maintenance to the instruments, and observed anomalies in

operation. Sample measurement data are entered into the Field Data Log Book. Content requirements for the Instrument Calibration Log Book for each appropriate instrument are included in the following sections of this manual:

1. Sect. 20.1, Calibration of Alpha Scintillators
2. Sect. 20.2, Calibration of Gas Flow Proportional Alpha Counters
3. Sect. 20.5, Calibration of Geiger-Mueller Survey Meters
4. Sect. 20.7, Calibration of Beta-Gamma Pancake Counters
5. Sect. 20.10, Calibration of Portable Gamma Scintillation Detectors
6. Sect. 20.19, Calibration of Mass Scales

Soil Sample Preparation Log Book

The ORNL-RASA laboratory contains the Soil Sample Preparation Log Book. This log book contains all information pertinent to receiving, drying, grinding, and bottling of soil samples. Content requirements for the Soil Sample Preparation Log Book are included in Sect. 15.8, Soil and Sediment Sample Preparation.

Air Pump and Mass Flow Meter Calibration Log Book

The ORNL-RASA laboratory contains the Air Pump and Mass Flow Meter Calibration Log Book. This log book contains all information pertinent to air pump and mass flow meter calibration and operational notes. Calibration values determined by ORNL-RASA as well as by the appropriate ORNL calibration facility are recorded in this log book. Operational notes include control settings, where applicable, repairs, adjustments, or maintenance to the air pumps and mass flow meters, and observed anomalies in operation. Sample measurement data are entered into the Field Data Log Book. Content requirements for the Air Pump and Mass Flow Meter Calibration Log Book for each appropriate piece of equipment are included in Sects. 13.9, Radon Measurements, and 20.18, Calibration of Air Pumps.

Wrenn Chamber Calibration Log Book

The ORNL-RASA laboratory contains the Wrenn Chamber Log Book. This log book contains all information pertinent to the laboratory calibration and operational notes for Wrenn Chambers. Operational notes include maintenance, repair, and special purpose calibration entries. Content requirements for the Wrenn Chamber Log Book are included in Sect. 20.15, Calibration of Wrenn Chambers.

Soil Sample Data Log Book

The ORNL-RASA laboratory contains the Soil Sample Data Log Book. This log book contains the records of all soil sample analysis results. Content requirements for the Soil Sample Data Log Book are included in Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples.

SUBJECT: PROJECT MANAGEMENT

Water Sample Data Log Book

The ORNL-RASA laboratory contains the Water Sample Data Log Book. This log book contains the records of all water sample analysis results. Content requirements for the Water Sample Data Log Book are included in Sect. 15.3, Determination of Radionuclides in Water Samples.

Soil Counter Tape (MAG Tape) Log Book

The ORNL-RASA laboratory contains the Soil Counter Tape (MAG) Log Book. This tape is a 9-track magnetic tape containing all the raw data from the N/D soil counting system. Details on the Soil Counter Tape (9-track) are included in Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples.

Soil Counter Tape (Paper Tape) Log Book

The ORNL-RASA laboratory contains the Soil Counter Tape (Paper) Log Book. This tape is a punched paper DEC tape containing all the raw data from the N/D soil counting system. Details on the Soil Counter Tape (Paper Tape) are included in Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples.

N/D System Sample Counting Log Book

The ORNL-RASA laboratory contains the N/D System Sample Counting Log Book. This log book contains records of sample counting chronology. Content requirements for the N/D System Sample Counting Log Book are included in Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples.

5/11 System Sample Counting Log Book

The ORNL-RASA laboratory contains the 5/11 System Sample Counting Log Book. This log book contains records of sample counting chronology. Content requirements for the 5/11 System Sample Counting Log Book are included in Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples.

Project file

The project file consists of several indexed folders including:

1. Historical data
2. Maps and facility drawings
3. Photography
4. Survey plans & correspondence
5. Private properties
6. Pre-survey visit
7. Raw data from formal survey
8. Review comments
9. Report
10. Analytical results

In addition, some sites may have folders on:

1. Nondisclosure agreement
2. Drilling log
3. Property owner consent-to-survey forms

Historical data. The historical data folder includes all background information on the site. Most of this information is provided by DOE. Some of the information comes from the owners or original owners of the site. Additional information may be obtained during the initial site visit and interviews. See Sect. 11.1, Evaluation of Site Records and Data.

Maps and facility drawings. The maps and facility drawings folder will contain drawings of the plant or facility layout, drawings of the site, and building drawings. The information included in this folder is determined during the initial site visit.

Photography. The photography folder contains historical photographs, as well as photographs taken during the initial site visit and the formal survey. Photographs are normally taken of any contaminated area from a number of perspectives. See Sect. 13.13, Field Photography.

Survey plans and correspondence. The survey plans and correspondence folder contains a copy of the radiological survey plan and all correspondence related to the site survey.

Private properties. The private properties folder contains information relating to vicinity properties associated with a candidate site.

Presurvey visit. The presurvey visit folder contains a copy of the preliminary survey report.

Raw data from formal survey. The raw data from formal survey folder contains any bits and pieces of data relevant to the site that may not have been saved in other parts of the project records for the site.

Review comments. The review comments folder contains any review or comments received from DOE regarding the site survey plan or reports.

Report. The report folder contains a copy of the radiological survey report on the site.

Analytical results. The analytical results folder contains the results of any special analysis that may have been performed on samples from the site.

Nondisclosure agreement. The nondisclosure agreement folder is not in all project files. For some commercial properties, it is necessary to complete a nondisclosure agreement to gain access to the site and site records.

Drilling log. The drilling log folder contains all information concerning site drilling.

U.S. Soil Sample Background Record Book

The U.S. Soil Sample Background Record Book contains a compilation of all background soil samples. These samples are organized by state. Content requirements for the U.S. Soil Sample Background Record Book are included in Sect. 13.1, Background Measurements.

Sample archives

Following counting and analysis, soil and sediment environmental samples (water samples excluded) are stored in the ORNL-RASA archives for permanent retention. The samples are stored in bags and placed in steel barrels. An inventory sheet of the contents is kept in each barrel. A copy of the barrel contents is kept in the office files. In addition, the Soils Analysis Log Book has an entry for each sample identifying the barrel number in which the samples are archived. See Sect. 14.9, Storage of Environmental Samples.

Published reports

A folder is maintained of the master copy of all formal reports published by ORNL-RASA.

10.3 DATA STORAGE

10.3.1 Purpose

The purpose of this procedure is to describe the data storage system used in support of the ORNL-RASA program.

10.3.2 Applicability

This procedure applies to all data generated directly or indirectly in the ORNL-RASA program. Specific data locations are addressed in Sects. 10.2, Project Recordkeeping, and 16.3, Equipment Calibration Records.

10.3.3 References

1. Sect. 10.2, Project Recordkeeping
2. Sect. 16.3, Equipment Calibration Records

10.3.4 Definitions and Abbreviations

10.3.4.1 Definitions

DATA. Information in all forms including written, printed, visual, electronic, or mechanical.

Also see Sect. 1.5 of this manual, Terminology.

10.3.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

10.3.5 Responsibilities

1. The ORNL-RASA program manager is responsible for the implementation of this procedure.
2. The records technologist is responsible for maintaining the data storage system and ensuring the retrievability of data.
3. The site leader is responsible for all log books in his custody and to ensure that all site-related data are transferred to the records technologist at the conclusion of the project.
4. The laboratory technologist is responsible for the laboratory log books in his custody and to ensure transfer to the records technologist when the log books are filled.
5. The instrument technologist is responsible for the laboratory log books in his custody and to ensure transfer to the records technologist when the log books are filled.
6. The records technologist is responsible for the filing of all documents and the retrievability of all documents as directed by the ORNL-RASA program manager.

10.3.6 Procedure

All data generated, either directly or indirectly, and relating to ORNL-RASA program activities are retained at the ORNL-RASA laboratory, with the following three exceptions:

1. Site records, Equipment, and Winnebago and Scanning Van Log Books are retained at the site until project completion, or, in the case of log books dedicated to an instrument, until the log books are filled.
2. Records pertinent to instrument calibration and maintenance and vehicle maintenance, which are established and maintained by organizations external to ORNL-RASA, are retained by the organization generating the data.
3. Data transmitted to the ORNL Computer Center for the data reduction and calculation of ND GeLi system soil analysis are retained on disk by the Computer Center at their facility.

10.3.6.1 Written and Printed Data Storage

Site log books

All log books dedicated to a specific site including Field Data, Radon Data, and Scanning Van Log Books, are retained in the custody of the site leader or his designee until the completion of the project. When the project is in process, these log books are usually maintained at the site. Following completion of the project, the site leader transfers them to the records technologist for filing. All completed site information is filed and maintained by the records technologist.

Winnebago and scanning van log books

All log books normally associated with a van, including Alpha Smear Counter, NaI(Tl) Detector, Alpha Spectrometer, Portable Instrument, Drill Hole Logger, ORNL Cell, and Lucas Cell Log Books are maintained in the van until the log books are filled. Data pertinent to a specific site survey are transferred to site log books as the data are generated.

After the log books are filled, they are transferred by the instrument technologist responsible for the van to the records technologist.

ORNL log books

All log books normally retained by ORNL-RASA, including Instrument Calibration, Sample Preparation, Air Pump and Mass Flow Meter Calibration, Wrenn Chamber Calibration, ORNL and Lucas Cell Calibration, Soil Sample Data, Water Sample Data, ND System Sample Counting, and 5/11 System Sample Counting Log Books, are maintained in the custody of the laboratory technologist or instrument technologist primarily responsible for each of the specified instruments or analyses.

After the log books are filled they are transferred by the laboratory technologist or instrument technologist having custody of the log book to the records technologist.

10.3.6.2 Visual Data Storage

Visual data, consisting of maps, photographs, and drawings concerning a specific site, are retained in the project file folder by the records technologist.

1. Photographs are stored in the photography folder along with negatives placed in appropriate negative protectors.
2. Maps and drawings are stored in the maps and facility drawings folder.

10.3.6.3 Electronic Data Storage

Electronic data, consisting of nine-track magnetic tapes from the ND GeLi system and floppy disks from the Tennelec 5/11 system, are retained by the laboratory technologist responsible for the soil counting system. Both 9-track magnetic tapes and 5/11 system floppy disks are retained for a period of one year and are then returned to service to be reused.

Data from the ND GeLi system are transmitted to the ORNL Computer Center for appropriate data reduction and calculations. These data are retained on the ORNL computer disks until deleted by RASA personnel.

10.3.6.4 Mechanical Data Storage

Mechanical data consisting of punched paper tapes from the ND GeLi system are retained by the laboratory technologist responsible for the soil counting systems. Punched paper tapes are retained until all corresponding MONSTR output has been checked, then they are destroyed.

10.4 REPORTS AND PAPERS

10.4.1 Purpose

The purpose of this procedure is to provide guidance for publishing survey-related documents and reports of ORNL-RASA.

10.4.2 Applicability

All documents (e.g., reports) written by ORNL-RASA will follow this procedure and its references.

10.4.3 References

1. HASRD Procedures for Publications and Oral Presentations, October 1980
2. ORNL Style Guide, May 1974

10.4.4 Definitions and Abbreviations

HIGHLIGHT. An informative, independent brief that will satisfy the information needs of fellow scientists or sponsors and provide management with information for decision making.

UCN-10369. ORNL Document Approval Form.

UCN-9136. Administrative Print Shop Reproduction Request Form.

UCN-7262C. HASRD Publications Review Record.

ORNL. Documents presenting final technical information and given wide internal and external distribution.

ORNL-TM. Documents containing preliminary technical information and given limited external and internal distribution.

ORNL-CF (central files). Documents prepared for internal use only.

ORNL-RASA. Documents containing RASA radiological survey information.

Also see Sect. 1.5 of this manual, Terminology.

10.4.5 Responsibilities

All ORNL-RASA personnel responsible for authoring any of the documents covered by this procedure will comply with this procedure.

10.4.6 Procedure

10.4.6.1 Types of Reports

The following several types of reports or documents are produced by ORNL-RASA to issue information derived from its activities to the appropriate distributions. Refer to Exhibit 10.1 for a Summary of ORNL-RASA Publication Guidelines, which includes review, approval, distribution, and publication requirements.

Refer to data for ORNL-RASA Reports (Exhibit 10.2) for information on types of reports, document outlines, and approximate report size. For all documents, refer to References (1) and (2) (see Sect. 10.4.3) for detailed information concerning report style and publication.

Of the following, all reports [(1) through (5)] must have DOE-OOS approval prior to publication.

1. Letter Reports - Letter reports are documents issued by ORNL-RASA that have a limited DOE and internal distribution. Otherwise, the content of the letter reports may be as broad as several of the other types of reports. See data for ORNL-RASA Reports (Exhibit 10.2) for a listing of the various letter reports. These reports are usually published after approval by the ORNL-RASA program manager only.
2. ORNL Central File (CF) Memo - Any survey-related document may be issued as a CF memo; however, it is usually a report of a partial or complete survey and has a very limited internal distribution in addition to DOE.
3. ORNL Report (Topical) - The ORNL topical report is the treatment of a single subject and is the most widely distributed of the reports provided at Oak Ridge National Laboratory. For ORNL-RASA, it is usually a radiological survey report for a candidate site. A Highlights brief must be prepared by the author and submitted with an approval form to Laboratory Records. See Summary of ORNL-RASA Publication Guidelines (Exhibit 10.1).
4. ORNL-TM Report - ORNL-TM documents contain preliminary technical information and are given both internal and external distribution. The information represented and the manner of presentation should be worthy of possible abstracting and indexing as in Nuclear Science Abstracts. A Highlights brief must be prepared by the author and submitted with an approval form to Laboratory Records. See Summary of ORNL-RASA Publication Guidelines (Exhibit 10.1).
5. DOE Report - This report is issued under a DOE report reference number; as such, the content reflects DOE philosophy.
6. Technical Journal - The individual preparing a paper for a technical journal will use the format and style appropriate for the specific publication. Content is determined by the author.
7. Abstract and Paper for Professional Meeting - The format, content, review, and style of papers for professional meetings are the same as requirements for technical journals.

10.5 PUBLIC RELATIONS

10.5.1 Purpose

The purpose of this procedure is to establish the responsibilities and rules for public release of information concerning work activities of the ORNL-RASA program.

10.5.2 Applicability

This procedure applies to all ORNL-RASA program related activities and particularly those related to remote survey sites.

10.5.3 References

D-5-8, Standard Practice Procedures, Martin Marietta Energy Systems, News Release to Media

10.5.4 Definitions and Abbreviations

10.5.4.1 Definitions

ORNL-RASA PROGRAM MANAGER. The staff member assigned by the HASRD Division Director as the responsible individual having authority to conduct the RASA program at ORNL as required by the DOE.

SITE LEADER. The ORNL-RASA staff member assigned by the ORNL-RASA program manager as the individual having primary responsibility and authority for survey activities at a specified survey site.

Also see Sect. 1.5 of this manual, Terminology.

10.5.4.2 Abbreviations

DOE Department of Energy

Also see Sect. 1.5 of this manual, Terminology.

10.5.5 Responsibilities

10.5.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for survey activity information releases to the public from ORNL.

10.5.5.2 Site Leader

The site leader is responsible for survey activity information release to the public at the survey site location.

SUBJECT: PROJECT MANAGEMENT

10.5.6 Procedure

1. At ORNL, the ORNL-RASA program manager is the only representative who may communicate with the media and public. He will release information only of a general nature concerning group activities and refer only to technical data approved by DOE for public release.
2. At the survey site, the site leader is the only representative who is authorized to communicate with the media and the public in reference to official business. As such, the site leader is not authorized to discuss the results of any survey activities but may discuss the following:

   a. Group identification
   b. Group affiliation (ORNL)
   c. Estimated time of survey activities
   d. Identification of survey individuals
   e. Identification of work authorization (DOE)
   f. Description of survey team activities
   g. The site leader will refer other technical questions to the ORNL-RASA program manager or to the DOE and may inform the media or the public of the issues he/she is authorized to discuss.

Exhibit 10.1. Summary of ORNL-RASA publication guidelines.[a,b]

Document	Distribution	Editing	Publication and clearance forms required	Final manuscript copies required
Letter report	Internal/DOE	Yes	UCN-10369 UCN-9136	One for division files
CF memo	Internal	Yes	UCN-10369 UCN-9136	One for division files
ORNL	Internal/external	Yes	UCN-10369 UCN-9136	One for division files
ORNL-TM	Internal/highlights external(key word)	Yes Yes	UCN-10369 UCN-9136	One for division files
DOE	Internal/external	Yes	UCN-10369 UCN-9136	One for division files
Technical journal		Optional	UCN-10369	Three for Laboratory Records, one for division files, one for division director
Speech abstract		Optional	UCN-10369	Three for Laboratory Records, one for division files

[a]All documents must be technically reviewed by a minimum of two peer reviewers; All documents must be approved by the appropriate group leader, section head, division director, classification officer, and patent officer and must be recorded in the Laboratory Records Department; and all documents should meet the requirements of the program for which the document is written.

[b]The procedures for ORNL/NUREG and ORNL/NUREG/TM reports are the same as those for the ORNL and ORNL/TM reports, respectively. All ORNL and TM technical reports (with the exception of strictly progress reports) will require a Highlights, which must be submitted to Laboratory Records for approval.

Exhibit 10.2. Data for ORNL-RASA reports.

SURVEY RELATED DOCUMENTS	TYPE OF REPORT					APPROX. NO. OF PAGES			OUTLINE CONTENT REFERENCE EXHIB.
	Letter Report	CF Memo	ORNL Report	ORNL-TM Report	DOE Report	Text	Figures	Tables	
1. Mobile Scan Survey Plan	X					3	2		10.5-4
2. Mobile Scan Survey Report	X					3	8	6	10.5-7
3. Preliminary Survey Plan (C)*	X					4	2		10.5-4
4. Preliminary Survey Report (C)	X					5	2	2	10.5-3
5. Radiological Survey Plan (C,V)*	X					5	2		10.5-4
6. Radiological Survey Report (C,V)	X	X	X	X	X	10	10	10	10.5-6
7. Post Remedial Action Survey Plan	X					3	2		10.5-4
8. Post Remedial Action Survey Report	X	X				15	2	6	10-5-5

*C - Candidate, V - Vicinity

Examples of Reports for Content Reference:

1) Action Plan for Mobile Gamma Ray Scanning, Rifle and Durango, CO, October 15, 1981.

2) Results of the Mobile Gamma-Ray Scan of Durango, CO, April 1982.

3) Preliminary Radiological Survey Plan of the Staten Island Warehouse at Port Richmond, NY, July 1980.

4) Preliminary Site Survey Report for Former Superior Steel Mill at Carnegie, PA, April 1981.

5) Radiological Survey Plan for the Former Superior Steel Mill at Carnegie, PA.

6) DOE/EV-0005/17; Radiological Survey of the Former Simonds Saw & Steel Co., Lockport, NY, November 1979.

7) Post Remedial Action Survey Plan for Middlesex Vicinity Properties (Draft), August 17, 1981.

8) Results of the Post-Remedial Action Survey of 312 Mountain Avenue (Kay's property) in Middlesex, NJ, October 1981.

SUBJECT: PROJECT MANAGEMENT

Exhibit 10.3. Preliminary survey report outline and content discussion.

1. INTRODUCTION

This section of the report explains the purpose of the survey and when and by whom it was conducted. A brief discussion regarding the MED and/or AEC contract work conducted at the site or associated with the site contamination should be included. Ideally, the material processed at the site and its sources and destinations should be included as well as any records of former surveys or decontamination efforts. The location of any equipment or decontamination and/or process residues should be reported.

All reports should contain a map with enough detail that the facility can be located on a published street map. Any pictures or diagrams relating to the former MED and/or AEC operations may be included here, or, if they are too voluminous, appended to the report and referenced here.

2. SITE DESCRIPTION

The site description contains a brief description of the site in its present condition and information on the use of the grounds, buildings, and any equipment used for the MED/AEC operations. In addition, information regarding occupancy of the buildings and grounds (especially for any contaminated areas) should be presented. Any known planned changes or anticipated future uses of the site should be outlined. It would also be desirable to describe the environs of the site (i.e., neighboring properties) in this section.

A diagram of the facility may be included if it would aid in the descripticn of the site. Owner and/or company contacts and those assisting ORNL-RASA in the survey effort should be mentioned here as well.

3. DESCRIPTION OF SURVEY PROCEDURES AND RESULTS

A very brief description of the survey equipment and methodology should be presented; however, this section should emphasize the results rather than the procedures. The text should summarize the radiation levels found at the site and background levels found nearby. Diagrams showing the areas of the buildings or grounds surveyed are to be included in this portion of the report. Detailed measurements should be placed on the diagram or in a table referencing the diagram of the facility. Similar reporting procedures should be followed for soil and water samples, including the comparison to background concentrations.

Exhibit 10.3 (Continued).

4. CONCLUSIONS AND RECOMMENDATIONS

This section should contain a summary of the findings and recommendations of ORNL-RASA. The following questions should be answered here:

1. Was any contamination found and how does it compare to background and standards?
2. Is there any foreseeable present or potential health hazard?
3. Are any additional surveys required and why?
4. Are there any conditions at this site that require special consideration on the part of DOE?

Sites surveyed should fall into two categories, those requiring comprehensive surveys (contaminated or possibly contaminated) and those requiring no additional surveys (radiologically clean sites or controlled, i.e., licensed). If a comprehensive survey will not produce useful information but the isolated contamination found in the preliminary survey should be removed, ORNL-RASA should indicate this in the report. The report should make a recommendation that no additional surveys should be conducted but that a remedial action should be considered.

The size of the preliminary survey report is flexible, but it should contain about three to six pages of text, a minimum of two figures (one showing the general location of the site and another more detailed diagram showing buildings, location of measurements taken, soil and water samples collected, and so forth), and any pictures of the facility that support the findings of the report. Pertinent historical data such as past surveys or certifications should be referenced or appended to the report.

Exhibit 10.4. An outline for survey planning reports.

Introduction and basis

Survey measurements planned

Measurement locations
Instrumentation
Types of measurements

- Surfaces
- Soil sampling, if required
- Background
- Mobile gamma scanning, if required

Post survey activities

- Sample analysis
- Data reduction and survey results
- Report preparation

References
Figures
Tables

Exhibit 10.5. Postremedial action survey report outline.

Introduction

Survey methods

Survey results

- Postremedial action but prior to restoration
- Post-Restoration

Significance of findings

References
Figures
Tables

SUBJECT: PROJECT MANAGEMENT

Exhibit 10.6. Radiological survey report outline and content discussion.

1. INTRODUCTION

Purpose of survey

1. When survey was conducted and by whom.
2. Brief history of site, or if it is a vicinity property, a history of the associated candidate site; include process history, if appropriate.
3. Description of property; include area maps and site-scaled drawings and photographs using care not to give away vicinity site location or ownership. Use code for all reference to vicinity of site locations.

2. SURVEY METHODS

Include and/or reference appendices that give:

1. Details of the survey plan for the site
2. Details of the survey instrumentation and sample analysis methods employed

3. SURVEY RESULTS

Subsections should provide a discussion of results for each measurement type. Text should summarize data in terms of range of results, average measured levels, and maximum levels observed. Reference to appropriate figures and detailed data tables should be provided. For onsite measurement results, comparisons to normal background levels should be mentioned in these sections. Additional specific requirements for each section are provided as follows:

3.1 BACKGROUND RADIATION LEVELS

Brief description of areas included in background determination

3.2 INDOOR SURVEY RESULTS

1. Measurements of external radiation levels
2. Radon and radon daughter sampling
3. Subsurface investigations - reference to appendix on hole-logging graphs
4. Other samples such as tap water, drain residues, wood, etc.

SUBJECT: PROJECT MANAGEMENT

Exhibit 10.6 (Continued).

3.3 OUTDOOR SURVEY RESULTS

1. Measurements of external radiation levels
2. Surface soil sampling
3. Subsurface investigations - reference to appendix on hole-logging graphs
4. Other samples such as core-hole water, vegetation, etc.

4. APPLICABLE RADIATION GUIDELINES

Summarize the governing regulatory bodies as well as the primary regulations applying to the site. Reference a summary table of guidelines and appendix giving complete citations.

5. SIGNIFICANCE OF FINDINGS

Provide introductory paragraph stating that based on the results of the survey, the following information can be derived:

5.1 EXTENT OF CONTAMINATION

Provide discussion and graphic displays of the extent of contamination indoors and outdoors. Provide table of contaminated areas (referenced to figure) giving breakdown of estimated area involved, depth of contamination in each area, and total volume of material present above the applicable guidelines.

5.2 EVALUATION OF RADIATION EXPOSURES

Summarize the bases for evaluation, assumptions used, and preliminary calculated estimate of the increased risk to individuals onsite. Reference the detailed exposure evaluation appendix.

6. SUMMARY

Provide a brief, executive-type summary of survey results, including overall summary tables for indoor and outdoor results. Give brief statement on exposure evaluation results. Include as appropriate the following:

References
Figures
Tables

SUBJECT: PROJECT MANAGEMENT

Exhibit 10.6. (Continued).

Appendices

Include as appropriate the following:

I. Definitions and units of measurement
II. Survey plan
III. Instrumentation/analysis methods
IV. Applicable radiation guidelines
V. Auger-hole gamma-ray logging graphs
VI. Evaluation of radiation exposures
VII. Any pertinent data results by other investigators

SUBJECT: PROJECT MANAGEMENT

Exhibit 10.7. Mobile scan survey report outline.

Introduction

- General
- Purpose

Survey methods

- Instrumentation
- Scanning methods

Survey results

- Scope of activities
- Scan results

Significance of findings

References
Figures
Tables

11. PRE-SURVEY ACTIVITIES

SUBJECT: PRE-SURVEY ACTIVITIES

11. PRE-SURVEY ACTIVITIES

11.1 EVALUATION OF SITE RECORDS AND DATA

11.1.1 Purpose

The purpose of this procedure is to provide guidance in the evaluation of site records and data.

11.1.2 Applicability

This procedure applies to all historical records and data relative to ORNL-RASA program sites.

11.1.3 References

Sect. 11.3, Identification of Subcontractor Requirements

11.1.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

11.1.5 Responsibility

The site leader is responsible for the implementation of this procedure.

11.1.6 Procedure

11.1.6.1 Objectives

The basic objectives of the evaluation of site records and data are to:

1. Determine if radioactive contamination exists
2. Identify the types of radioactive contaminants that may exist on the site
3. Determine where the radioactive contaminants may be located
4. Estimate the extent of radioactive contamination

11.1.6.2 Records and Data Acquisition

Both historical and contemporary data and records are secured to assist in the process of reaching the basic objectives. Data and records are supplied or must be secured from DOE.

The records and data acquired for evaluation include:

1. Historical site records, including processes employed on the site, storage and production products, area, etc.
2. Plats
3. Aerial and surface photographs
4. Radiological surveys (aerial and surface)
5. Facility blueprints
6. Topographical maps
7. Street/road maps
8. Occupancy of potentially contaminated areas

Historical and contemporary records and data are secured to indicate major topographical or structural changes to the site.

11.1.6.3 Records and Data Inspection and Consolidation

Historical and contemporary records and data are inspected and consolidated into a more concise form by making notes and sketches concerning data pertinent to site areas and structures that are potential locations of radioactive contamination.

11.1.6.4 Records and Data Evaluation

Consolidated records and data are evaluated, referring to original documents as necessary, to determine:

1. What occurred at the site and the current site usage (processes, products, etc.)?
2. What are the current site physical conditions (brush, rubble, weeds, and other conditions requiring special action)?
3. Have any significant conditions on the site (topographical or structural) been changed since its use as an active facility that may affect a radiological survey?
4. Site size and complexity.
5. Which areas or structures on the site are most likely to be sources of radioactive contamination, and what is the normal occupancy of these areas?
6. How much contamination may exist on the site (in terms of volume of contaminated material)?
7. What are probable radioactive contaminants on the site (usually radium, uranium, or thorium)?

11.1.6.5 Resource Information

Based on the preceding steps of this section, a determination can now be made concerning future site activities relative to a subsequent site survey. Some of these determinations include:

1. Will time constraints placed by the ORNL-RASA program manager on the site survey(s) be adequate?
2. Will subcontractors be required? See Identification of Subcontractor Requirements, Sect. 11.3.
3. What size survey team will be required?
4. What equipment may be required in addition to the normal complement utilized in the survey?
5. Based on the geographical area and season, what clothing requirements are needed?
6. Which planning procedures can be implemented before the field survey?

11.2 SPECIFICATION OF MEASUREMENT GRID SYSTEM AND MAPS

11.2.1 Purpose

The purpose of this procedure is to provide a method for the establishment of a measuring grid system and maps for radiological surveys.

11.2.2 Applicability

This procedure applies to all ORNL-RASA radiological surveys.

11.2.3 References

1. Sect. 11.3, Identification of Subcontractor Requirements
2. Sect. 18.1, Procurement of Services and Equipment
3. Sect. 18.2, Administration of Subcontracts
4. Sect. 18.3, Subcontractor Reporting

11.2.4 Definitions and Abbreviations

11.2.4.1 Definitions

GRID. A network of parallel horizontal and vertical lines forming squares on a map; may be overlaid on a property parcel for the purpose of identification of exact locations.

GRID BLOCK. A square defined by two adjacent vertical and two adjacent horizontal grid lines.

GRID POINT. The intersection of horizontal and vertical grid lines and/or the intersection of a grid line and the perimeter of a structure.

Also see Sect. 1.5 of this manual, Terminology.

11.2.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

11.2.5 Responsibilities

The site leader is responsible for the implementation of this procedure.

11.2.6 Procedure

11.2.6.1 Outdoor Grid System

Selection of baseline

The grid baseline is generally selected to be the longest dimension on the property. It is preferred to have the baseline coincident with a property boundary, although this is not a requirement. Examples of baseline placement are illustrated in Outdoor Grid Baselines (Exhibit 11.1).

Grid block dimensions

ORNL policy prefers the use of metric system measurements (m), although the English system measurements (ft) are acceptable. Most surveyors continue to use the English system.

Grid dimensions are established with the following constraints:

1. Maximum grid block dimension is 100 ft (distance between consecutive grid points).
2. Minimum statistically acceptable number of grid points is 30.
3. Preferred number of grid points is 60 to 100.

Grid marking

As grid points are established, they are identified by a marking system that is appropriate to the terrain. These markers include:

1. Stakes prepared from lath wood
2. Tape
3. Survey markers
4. Concrete nails with bright (red, orange) ribbons

Grid point identification

Following the establishment of the grid baseline and the grid dimensions, the grid is laid out on the property and marked according to Sect. 6.1.3. Any intersection of a grid line with a structure is designated as a grid point to assist in establishing exact structure placement with respect to the grid system. See Outdoor Grid (Exhibit 11.2).

Points on the grid system are identified in a standard manner. See Outdoor Grid Point and Block Identification (Exhibit 11.3). The first digit or set of digits refers to the distance from the 0,0 baseline point on the baseline. The second digit or set of digits and an L or R (separated from the first set by a comma) relates to the distance from the baseline with the L or R referring to the direction (left or right) from the baseline. Point A on Outdoor Grid Point and Block Identification (Exhibit 11.3) is identified 2+00, 100R.

Fractional distances between points are included following the grid point number using the same units as used in the grid dimension. Fractional distances between grid points are identified by adding the distance beyond the grid point using the same units as used in grid dimensions. Point B on Outdoor Grid Point and Block Identification (Exhibit 11.3) is identified 1+30, 25R.

Grid block identification

Grid blocks are normally identified by the grid point in the lower right-hand corner. See Outdoor Grid Point and Block Identification (Exhibit 11.3). The shaded grid block is identified 2+00, 100L in the exhibit. Grid blocks found to contain areas exhibiting elevated radiation levels may be subdivided for accuracy according to this procedure (using smaller grid dimensions). Subdivided grid blocks are identified by the grid point in the lower right corner using the fractional distances specified in Sect. 6.1.4 of this procedure.

Property size

Depending on property size, complexity and terrain, the layout of the grid system may be accomplished by ORNL-RASA members or by subcontracted surveyors.

Grid for over-5-acre parcels. The grid for over-5-acre parcels is established under subcontract by a surveyor. The surveyor is instructed to set the grid in accordance with the requirements of this procedure, to tie the grid in to the state or county plat system, and to lay out the exact property boundary. See Sect. 11.3, Identification of Subcontractor Requirements; Sect. 18.1, Procurement of Services and Equipment; Sect. 18.2, Administration of Subcontracts; and Sect. 18.3, Subcontractor Reporting.

Grid for under-5-acre parcels. The grid for under-5-acre parcels is generally established by ORNL-RASA personnel in accordance with the requirements of this procedure. Typical parcels in this category are residential and small commercial properties.

If the complexity of the property (including terrain, structures, and conditions) prohibit an accurate grid system to be established by ORNL-RASA personnel, the site leader may elect to have the grid system established by a subcontracted surveyor in accordance with the requirements of this procedure.

11.2.6.2 Indoor Grid System

Selection of baseline

The grid baseline is generally selected to be the longest dimension of the structure. The baseline is selected to be coincident with an exterior wall of the structure. Line 0 is set as the baseline, as illustrated in Indoor Grid Point and Block Identification (Exhibit 11.4).

Grid dimensions

ORNL policy prefers the use of metric system measurements (m), although the English system measurements (ft) are acceptable.

Grid dimensions are based on the following constraints:

1. Maximum indoor grid dimension is 25 ft.
2. Minimum statistically acceptable number of grid points is 30.
3. Preferred number of grid points is 60 to 100.

Grid marking

As grid points (intersection of horizontal and vertical grid lines) are established, they are identified by a marking system appropriate to the floor construction of the structures. Tape markers are generally used to prevent structural damage.

Grid point identification

Points on the grid system are identified in a standard manner. See Indoor Grid Point and Block Identification (Exhibit 11.4). The use of an alphanumeric system is used in the indoor grid system to avoid confusion with the exterior grid system. The interior and exterior grid systems are independent and contain no designed common points. The first digit or set of digits refers to the distance from the 0,0 baseline point. The second alpha character or set of characters (separated from the first set by a comma) relates to the distance from the baseline. Point A on Exhibit 11.4 is identified as 4,D.

Fractional distances between points are included following the given point number or alpha characters, using the same units as used in the grid system. Fractional distances between grid points are identified by adding the distance beyond the grid point, using the same units as used in grid dimension. Point B on Indoor Grid Point and Block Identification (Exhibit 11.4) is identified as 6,C+2.

When the grid system includes a structural wall, this is identified by including a descriptive term in the grid identification. Point C in Exhibit 11.4 would be referenced as BL,C (wall).

Grid block identification

Grid blocks are identified by the grid point in the lower right-hand corner. See Exhibit 11.4, Indoor Grid Point and Block Identification. The shaded grid block is identified as 8,B in the exhibit. Grid blocks found to contain areas of elevated radiation levels may be subdivided for accuracy according to this procedure (using smaller grid dimensions).

Structure size

The interiors of small rooms (<500 ft^2) are not placed on the grid. All other rooms of the structure are placed on the grid.

11.3 IDENTIFICATION OF SUBCONTRACTOR REQUIREMENTS

11.3.1 Purpose

The purpose of this procedure is to provide a method of identifying subcontractor requirements for ORNL-RASA radiological surveys.

11.3.2 Applicability

This procedure applies to all ORNL-RASA program projects requiring the services of subcontractors.

11.3.3 References

1. Sect. 4.1, Preliminary Survey Planning
2. Sect. 6.1, Preparation of Candidate Site Survey Plan
3. Sect. 7.1, Preparation of Post-Remedial Action Survey Plan
4. Sect. 8.1, Identification and Planning of Support Functions
5. Sect. 11.1, Evaluation of Site Records and Data
6. Sect. 11.2, Specification of Measurement Grid System and Maps
7. Sect. 18, Subcontract Services and Administration

11.3.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

11.3.5 Responsibilities

The site leader is responsible for the implementation of this procedure.

11.3.6 Procedure

The determination of subcontractor requirements is an integral function of planning procedures including: Sect. 4.1, Preliminary Survey Planning; Sect. 6.1, Preparation of Candidate Site Survey Plan; Sect. 7.1, Preparation of Post-Remedial Action Survey Plan; and Sect. 8.1, Identification and Planning of Support Functions. Additionally, the implementing procedures for pre-survey activities of Sect. 11.1, Evaluation of Site Records and Data, and Sect. 11.2, Specification of Measurement Grid System and Maps, are likewise related to this procedure.

11.3.6.1 Subcontractor Services

To determine the appropriate subcontractor required for a specific function, a knowledge of the various subcontractor functions is necessary. These functions include:

1. Industrial cleaning - structural (interior cleaning) before initiation of indoor surveys;
2. Landscaping maintenance - vegetation and rubble removal before conducting a survey;
3. Land surveying - establishing grid system, property lines, and base maps;
4. Construction contracting - earth and debris moving or removal and machinery and equipment moving;
5. Drilling and augering - provide subsurface sampling including augering and continuous core drilling;
6. Technical supporting functions - provide professional radiological health personnel, field survey technicians, and other support personnel as needed; and
7. Sample processing - preparation of samples (soil, etc.) for site analysis.

Subcontractor justification

The justification for the use of subcontractors on ORNL-RASA survey sites is based on the three factors described as follows:

1. Scope of task - if the type or quantity of work required in a task exceeds the equipment or manpower resources of ORNL-RASA, then a subcontractor is required to perform the task;
2. Cost effectiveness - if a subcontractor is cable of performing a task with quality equivalent to ORNL-RASA and at a lower cost to the project, a subcontractor may be considered to perform the task; and
3. Time effectiveness - if project time constraints may be exceeded unless additional resources are employed by subcontractor utilization, a subcontractor may be considered to perform a task.

SUBJECT: PRE-SURVEY ACTIVITIES

Decision points

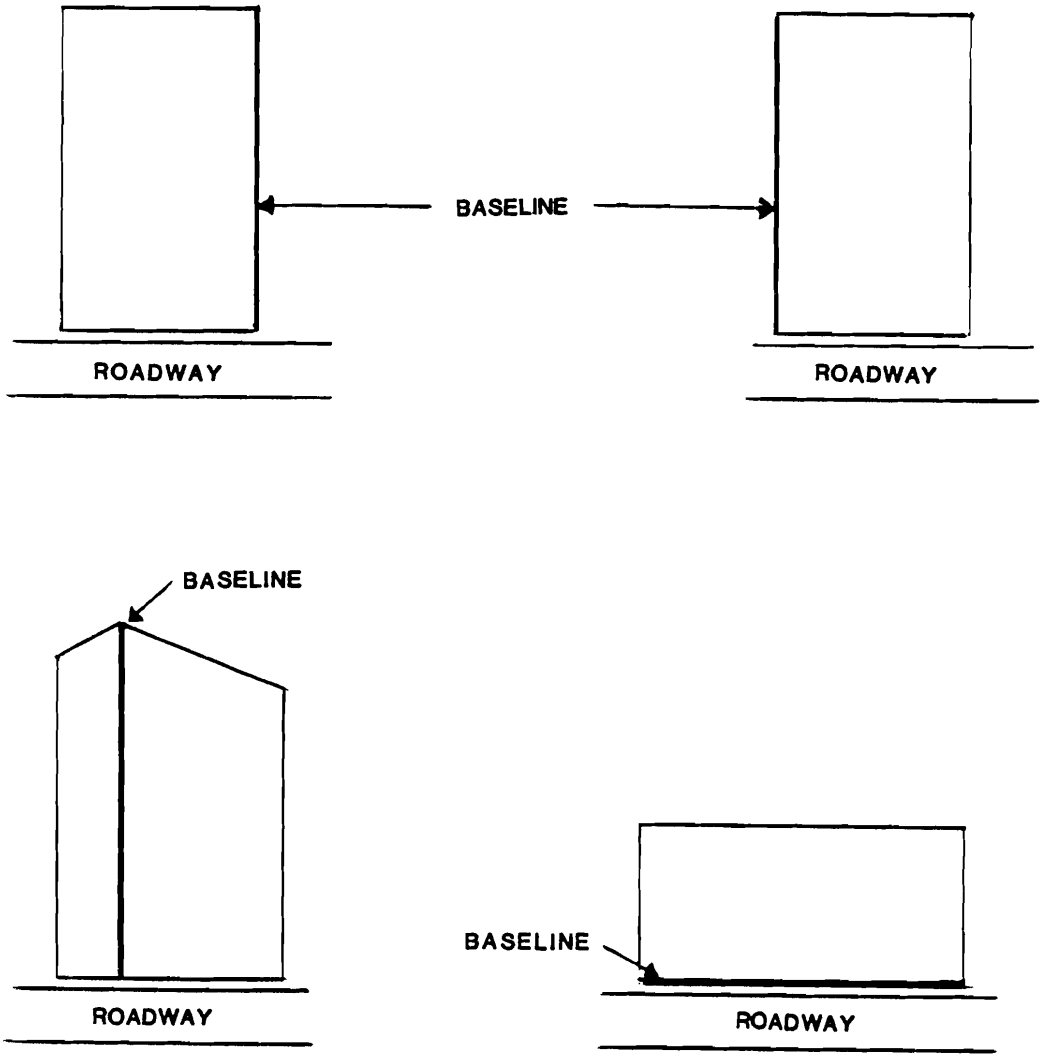
The determination of subcontractor requirements is, as stated in Sect. 6, an integral part of a number of planning and implementing procedures. The experience and judgment of the site leader must be fully utilized during the planning stages to determine the subcontractor requirements.

Evaluation of site records and data. During the review of historical and contemporary site information according to the procedure of Sect. 11.1, Evaluation of Site Records and Data, the site leader reviews documents in an effort to determine the current property size, landscape condition, significant amounts of rubble and debris on the site, and potential depth of contamination. Verification or suspicion of any of these conditions should be noted and retained for use in preliminary radiological survey planning.

Preliminary survey planning. During the preparation of the Preliminary Survey Plan according to the procedure of Sect. 4.1, Preliminary Survey Planning, subcontractor requirements are more explicitly defined as information determined by the procedure of Sect. 6.1.2.1 is incorporated into the plan. Additional information gained from any other sources is integrated into the survey plan. Time constraints are considered as task-subcontracting decisions are reached. The services of subcontractors necessary to the preliminary survey are enlisted following the procedures in Sect. 18, Subcontract Services and Administration.

Full radiological survey planning. During the preparation of the full radiological survey plan according to the procedure of Sect. 6.1, Preparation of Candidate Site Survey Plan, information determined during the preliminary survey is incorporated into the plan for the full radiological survey. Use of the firsthand onsite experience and preliminary radiological survey results permits the site leader to accurately define the subcontractor requirements for the remaining survey(s) (full radiological, postremedial action, and/or postrestoration) consistent with the subcontractor justifications described in Sect. 6.1.1 of this procedure. The identified tasks to be accomplished by subcontractors are awarded to the appropriate subcontractors following the procedures in Sect. 18, Subcontract Services and Administration.

Exhibit 11.1. Outdoor grid baselines.



SUBJECT: PRE-SURVEY ACTIVITIES

Exhibit 11.2. Outdoor grid.

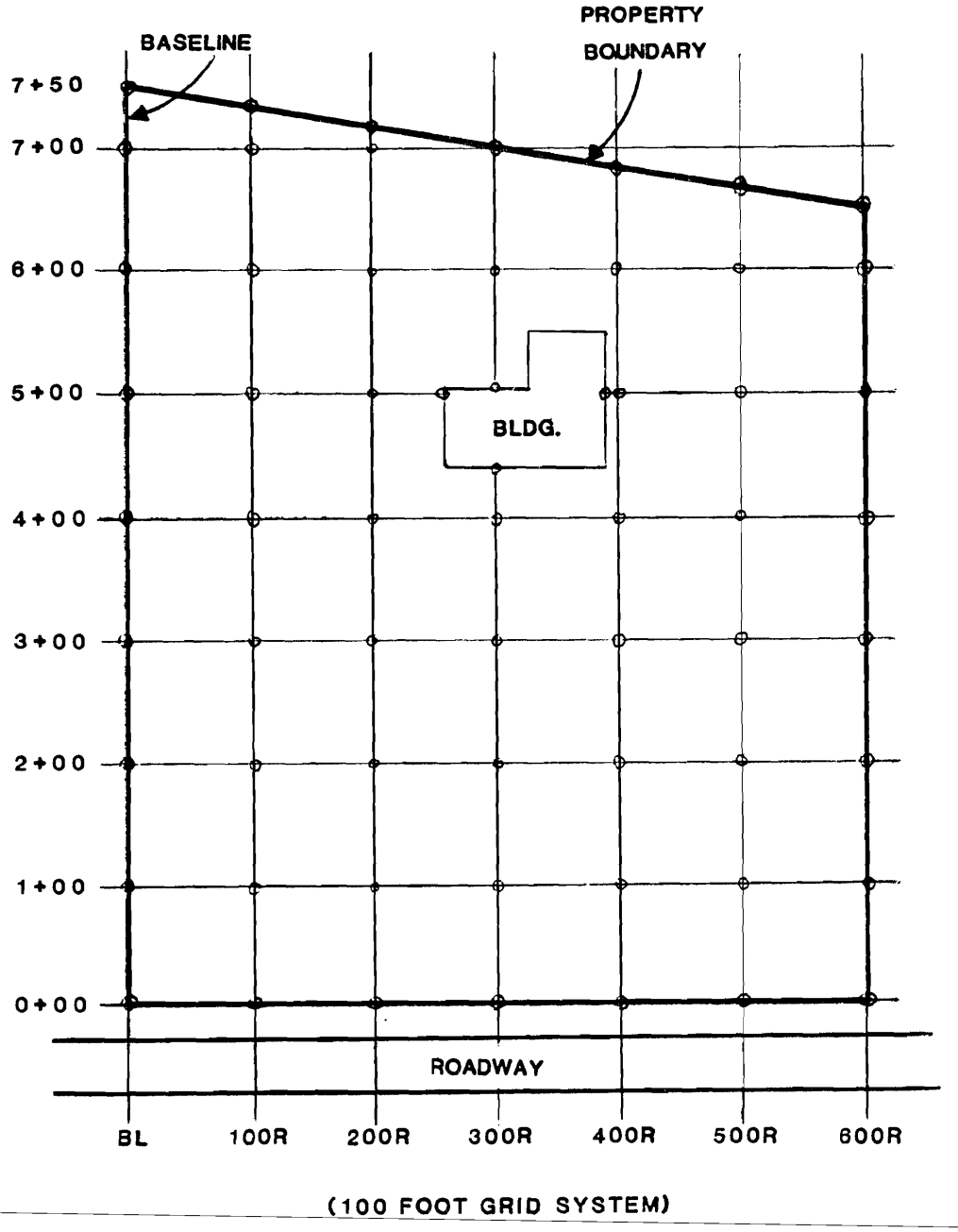
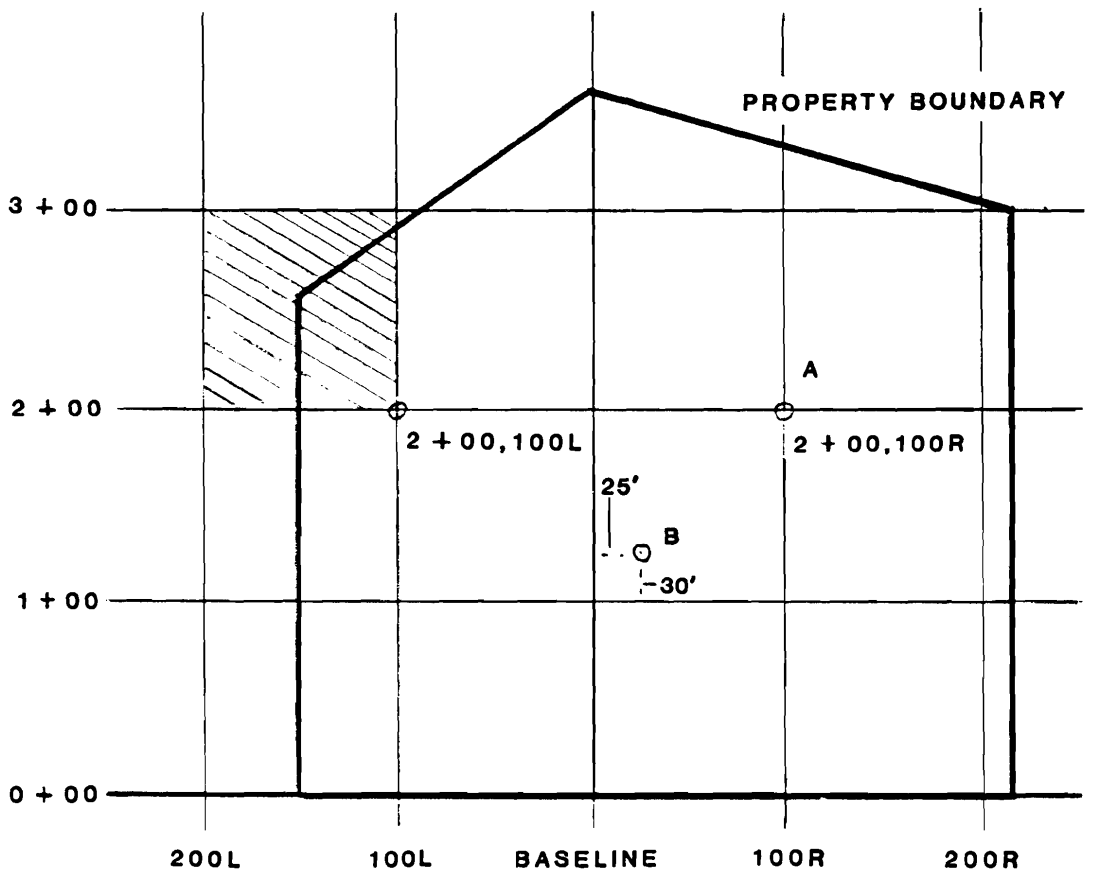


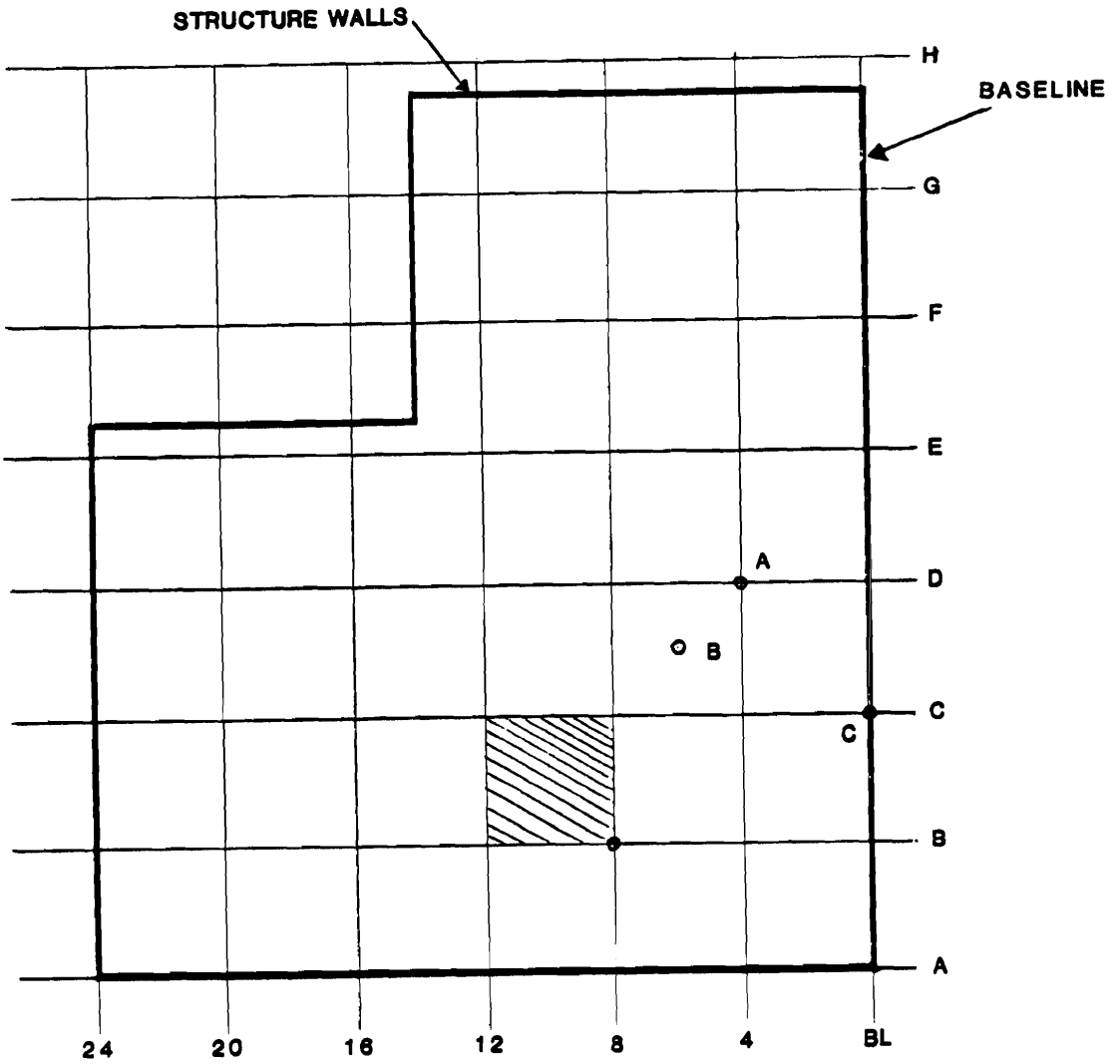
Exhibit 11.3. Outdoor grid point and block identification.



POINT A GRID IDENTIFICATION 2 + 00,100R
POINT B GRID IDENTIFICATION 1 + 30,25R
SHADED GRID BLOCK IDENTIFICATION 2 + 00,100L

100' GRID DIMENSION

Exhibit 11.4. Indoor grid point and block identification.



4 METER GRID

POINT A GRID IDENTIFICATION 4,D

POINT B GRID IDENTIFICATION 6,C+2

POINT C GRID IDENTIFICATION BL,C (WALL)

SHADED GRID BLOCK IDENTIFICATION 8,B

12. MOBILE GAMMA SCANNING VAN

12. MOBILE GAMMA SCANNING VAN

12.1 MOBILE GAMMA SCANNING VAN OPERATION

12.1.1 Purpose

The purpose of this procedure is to provide guidelines for operating the mobile gamma scanning van for vicinity properties identification.

12.1.2 Applicability

This procedure applies to the mobile gamma scanning van used by ORNL-RASA personnel for scanning and identification of vicinity properties.

12.1.3 References

Instruction manuals for the equipment listed in Sect. 6.1 of this procedure, to the extent available.

12.1.4 Definitions and Abbreviations

12.1.4.1 Definitions

INVERTER. A device for converting direct current to alternating current.

Also see Sect. 1.5 of this manual, Terminology.

12.1.4.2 Abbreviations

MCA Multi-channel analyzer

CRT Cathode ray tube - may refer to the computer CRT or MCA CRT in this procedure

Also see Sect. 1.5 of this manual, Terminology

12.1.5 Responsibilities

12.1.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager has overall responsibility for identification of vicinity properties.

12.1.5.2 Site Leader

The site leader is responsible for the planning and coordination of the mobile gamma scanning activities for identification of vicinity properties.

12.1.5.3 Scanning Team Leader

The scanning team leader is responsible for conducting the field scanning activities. He and two instrument technologists operate the van.

12.1.5.4 Mobile Lab Coordinator

The mobile lab coordinator is responsible for the readiness status of the mobile gamma scanning van and support systems before the van leaves for the site.

12.1.6 Procedure

12.1.6.1 Equipment, Apparatus, and Supplies

The mobile gamma scanning van and support systems consist of a modified Dodge Model 300 van that has a built-in gasoline-powered electric generator and associated instrumentation, lead storage batteries, battery charger, inverter and associated instrumentation, field office supplies, distance transducer, support equipment, and supplies (see Exhibit 12.1).

The gamma scanning instrumentation consists of the following:

1. Three 4 x 4 x 16 in. NaI(Tl) Polyscin Log Crystals having integral 3.5-in. photomultiplier tubes mounted on a lead-shielded, hydraulically operated carriage;
2. ORNL designed interface unit;
3. Commodore CBM Model 8032 Computer;
4. Commodore CBM 8050 Dual Drive Floppy Disk;
5. Commodore Tractor Model 4022 Printer;
6. MFE Strip-chart Recorder, dual pen with print head;
7. Tracor Northern Display Unit TN 1314;
8. Tracor Northern Pulse Height Analyzer, TN 1706;
9. Ortec Model 113 Preamplifier;
10. ORTEC AMP & SCA, Model 490B;
11. ORTEC LOG/LIN Rate Meter, Model 449;
12. ORTEC High Voltage Power Supply, Model 456, 0-3kV;
13. TENNELEC TENNEBIN 3, Bin Power Supply;
14. Distance transducer;
15. Audio alarm system;
16. Tl-208 Source, no specifications;
17. Co-60 Source, 14182.5, 11.00 uCi (1-1-74) Isotope Products Laboratories;
18. Cs-137 Source, 7286-5, 12.0 uCi (11-1-79) Isotope Products Laboratories;
19. Lead pig for Co-60 and Cs-137 sources; and
20. Floppy Disk Program, CBM Model 8050 Scan Program, 6/2/82 (or latest revision).

12.1.6.2 Equipment Setup

The detectors, compute and peripherals, pulse height analyzer components, and support systems are all interconnected and ready for operation. If, for some reason, component disconnect of reconnect is necessary, the scanning team leader may contact an instrument technologist at ORNL-RASA and obtain the necessary information to reconnect the system.

12.1.6.3 General Procedure

The following steps are typical in mobile gamma scanning:

1. Start instrument power supply system (see Sect. 6.4)
2. Turn on instrumentation (see Sect. 6.5)
3. Turn on data handling system (see Sect. 6.6)
4. Calibrate instrumentation (see Sect. 6.7)
5. Periodic check of distance transducer calibration (see Sect. 6.8)
6. System scanning operation (see Sects. 6.9 through 6.13)
7. System shutdown (see Sect. 6.14)
8. Field documentation (see Sect. 6.15)

The preceding steps are explained in detail in the referenced succeeding sections and photographs of the mobile gamma scanning van are provided as Exhibits 12.2 through 12.9.

For background information, a system description of the mobile scanning van is included as Exhibit 12.10. Exhibit 12.11 presents the computer program for data analysis and some useful computer commands.

12.1.6.4 Instrument Power Supply Startup

1. Start the generator by turning on the generator start switch located on the right driver overhead panel. Starting the generator will also activate the clock counter, which will register the number of hours the generator has operated. This counter will be checked by the garage to determine when maintenance is needed.
2. To monitor the condition of the batteries, check the battery charge indicator on the overhead panel above the driver's position and dash ammeter.
3. Turn on the inverter switch located on a panel below the computer. This is the top left switch on the panel.
4. Monitor the voltmeter and ensure that the power supply has stabilized at approximately 110 V before turning on the instrumentation.
5. Watch the voltmeter and frequency meter after generator startup. The voltmeter should indicate 110 V and the frequency meter should indicate 60 Hz (or cycles per second). Notify the scanning team leader if the readings are abnormal when the generator is under load. The ammeter will indicate the load placed on the system.
6. To ventilate the inverter compartment, turn on the blower switch (toggle).
7. When the scanning activities for the day are completed, turn off equipment power, inverter, and generator, in that order.

12.1.6.5 Gamma Scanning System Startup

1. Start instrument power supply as in Sect. 6.4.
2. Turn on instrument bin power.
3. Turn on interface unit power and push reset on the interface unit.
4. Turn on high-voltage power supply and raise to 1000 V in 500-V increments. Pause for 5 to 10 s at 500 V before increasing to 1000 V.
5. Raise the detectors to the full "up" position by pressing the top button on the hydraulic controller. The hydraulic controller is located on the wall just below the right-rear window of the scanning van. When the full up position is reached, a limit switch will stop the pump.
6. Insert the two safety pins into the detector frame (this may require using one or both of the hydraulic control buttons to position the holes so the pins can be inserted).
7. When the safety pins are inserted, push the down button of the controller to release the pressure from the hydraulic system.

12.1.6.6 Instrument Calibration

The scanning instrumentation is calibrated daily before any scanning is performed. If the system has been calibrated, proceed to any of the other program modes (Sects. 6.8 through 6.11). The procedure is detailed in Exhibit 12.29.

12.1.6.7 Distance Transducer Calibration

Calibration

1. Check tire pressures; each tire should have 75 psi. Record the tire pressure in the Scanning Van Calibration Log Book.
2. Lay out a stretch of road or street a minimum of 500 ft long. Mark the beginning and the end of the stretch along the curve and each 50-ft increment in between.
3. Drive the van to the starting point.
4. Mount the slow-moving-vehicle sign and turn on emergency flashers.
5. Set the computer system on calibration or identification mode.
6. When the operator signals ready, drive the van slowly toward the end point of the calibrated stretch.
7. Carefully stop the van at the end point of the stretch.
8. The operator reads the distance from the computer display.
9. Repeat this check procedure three to five times. If the computer display is ±3% of the true value (500 ft), the distance transducer is ready to be used.
10. If the readings are outside the range, the scanning team leader will notify the instrument technologist for further adjustments.

Documentation

Document the results of the calibration check for the distance transducer in the Scanning Van Calibration Log Book. For each calibration check, enter the information indicated in Exhibit 12.21.

12.1.6.8 Background Mode

The background mode of the scan program is accessed when determining the background radiation level to be used in establishing the "hit" criteria for an area to be scanned. Background radiation levels may be new (to be acquired) or old (previously determined). These two options are addressed in Exhibit 12.30.

12.1.6.9 Scan Mode

The scan mode of the scanning program is used to scan properties for anomalies. The procedure for scan mode operation is detailed in Exhibit 12.31.

12.1.6.10 Identification Mode

The identification mode detailed in Exhibit 12.32 is used to verify or obtain the exact location of hits. No data storage is provided for this mode of operation.

12.1.6.11 Data Dump Mode

This program mode (detailed in Exhibit 12.33) allows for the printing of all recorded raw data obtained during scanning from the disk in drive 1. No computer analysis of the data is performed.

12.1.6.12 File List Mode

The file list program mode detailed in Exhibit 12.34 will print out the computer analyzed data on a file basis for the disk in disk drive 1. This program mode has three options:

1. The scan data can be compared with the hit criteria that were used during the scan, resulting in a printout of the same summary that was provided from the scan mode. This option is accessed by typing U;
2. The scan data can be compared with new hit criteria input by the operator, resulting in a different analysis and summary of data. To access this option, type I and input the appropriate new hit criteria when called for; and
3. All the scan data, including the data on properties where a hit did not occur, are printed. This option can be accessed by typing N and entering 0 and pressing the RETURN key for each of the needed criteria.

12.1.6.13 System Shutdown

1. Remove disks from disk drives 0 and 1.
2. Turn off floppy disk system.
3. Turn off computer.
4. Turn off the strip chart power (2 switches).
5. Turn off the interface unit power.
6. Decrease high-voltage by 500 V increments to 0 V.
7. Turn off high-voltage power supply.
8. Turn off instrument bin power.
9. Turn off interface unit.
10. Remove safety pins under detector frame (may require use of hydraulic system controls to position detector).
11. Lower detectors to the lowest position, making sure that detector cables are free of obstructions (push in and hold the down button on the hydraulic controller).
12. Turn off the power inverter.
13. Turn off the generator.

12.1.6.14 Documentation

Documentation of the gamma scanning operation is mainly provided by the computer system, strip-chart recorder, and floppy disk systems. Data analysis is also provided by the computer system with hard copy printout. The printout and any notes are filed as part of the gamma scanning operation records. The printouts are attached to the Scanning Van Log Book. See the section on Data Storage in Exhibit 12.10 for more details.

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.1. Mobile scanning van support equipment and supplies.

Office supplies

1. Stapler and staples
2. Three-hole paper punch
3. Paper clips
4. Tape, masking and Scotch
5. Pens, pencils, colored pencils
6. 3-ring binders with inserts

Van accessories

1. Tire wrench
2. First aid emergency kit
3. Quart of oil
4. Two-ton hydraulic jack
5. Tire pressure gauge, to 100 psi
6. Waste basket
7. Road map
8. Slow-moving-vehicle sign

Electronic tools

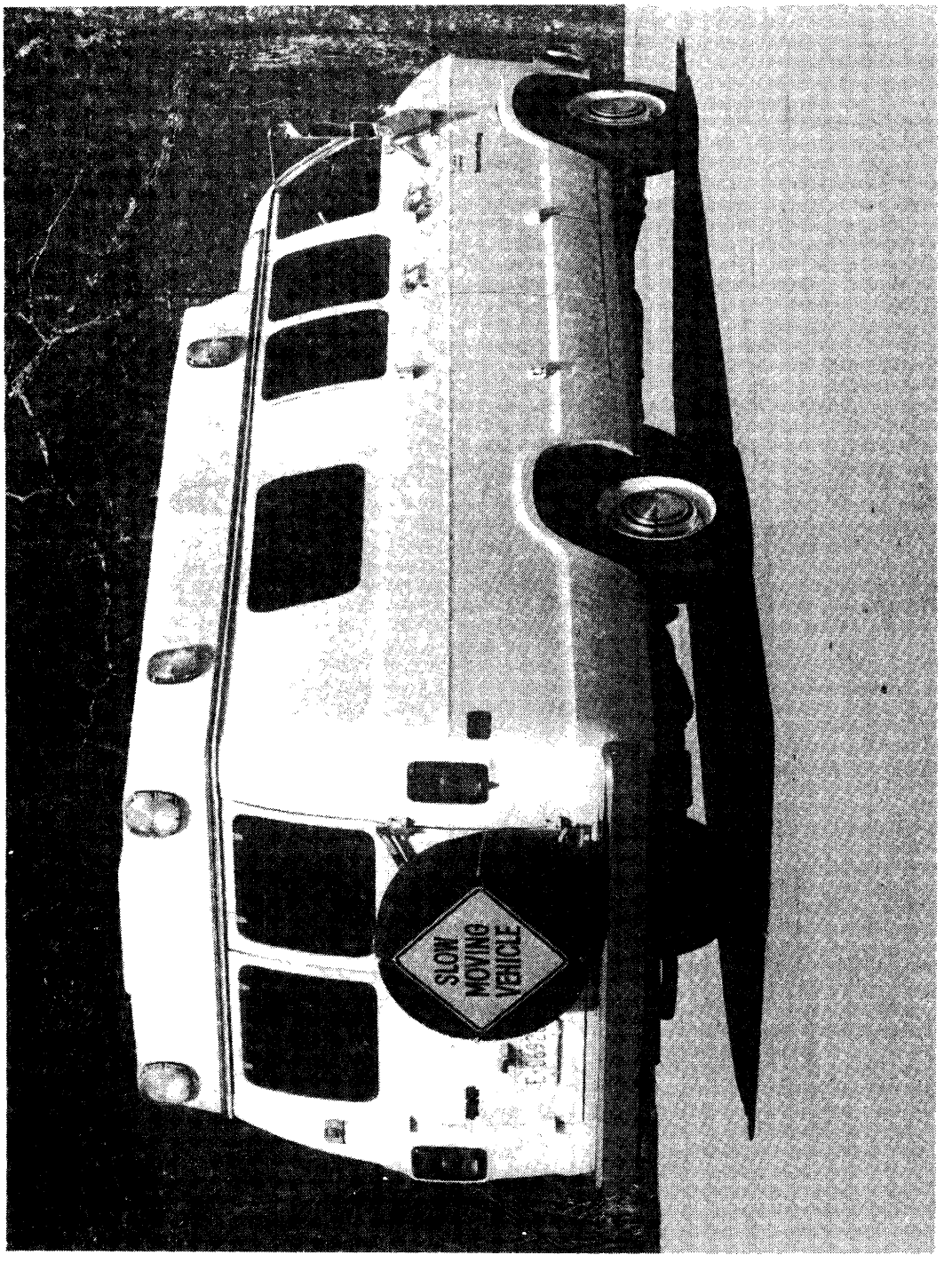
1. Voltmeter (VOM)
2. Tool kit (pliers, cutter, soldering iron, screw driver)
3. ORTEC Model 448 Research Pulser
4. Digital voltmeter
5. Oscilloscope
6. Frequency counter

Scanning supplies and backup equipment

1. Tractor printer paper
2. MFE strip chart recorder paper
3. Blank diskettes
4. Backup electronics components
    a. Ortec High Voltage Power Supply Model 456, 0-3kV
    b. Ortec AMP & SCA, Model 490B
    c. Ortec LOG/LIN RATEMETER, Model 449
    d. Ortec Model 113 Preamplifier
    e. Tracor Northern Multichannel Analyzer 1706 and Model 1314 CRT

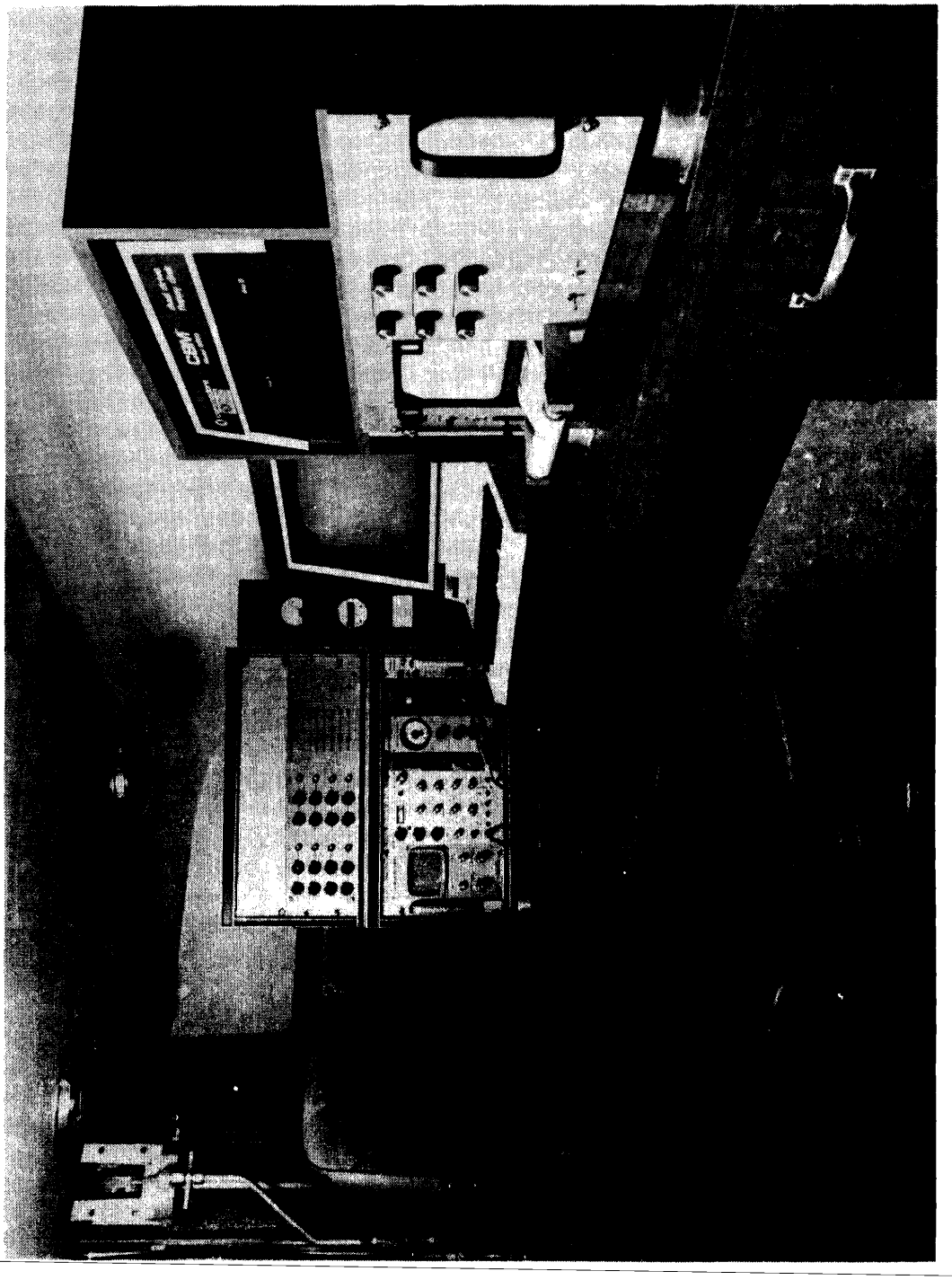
SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.2. Mobile gamma scanning van.



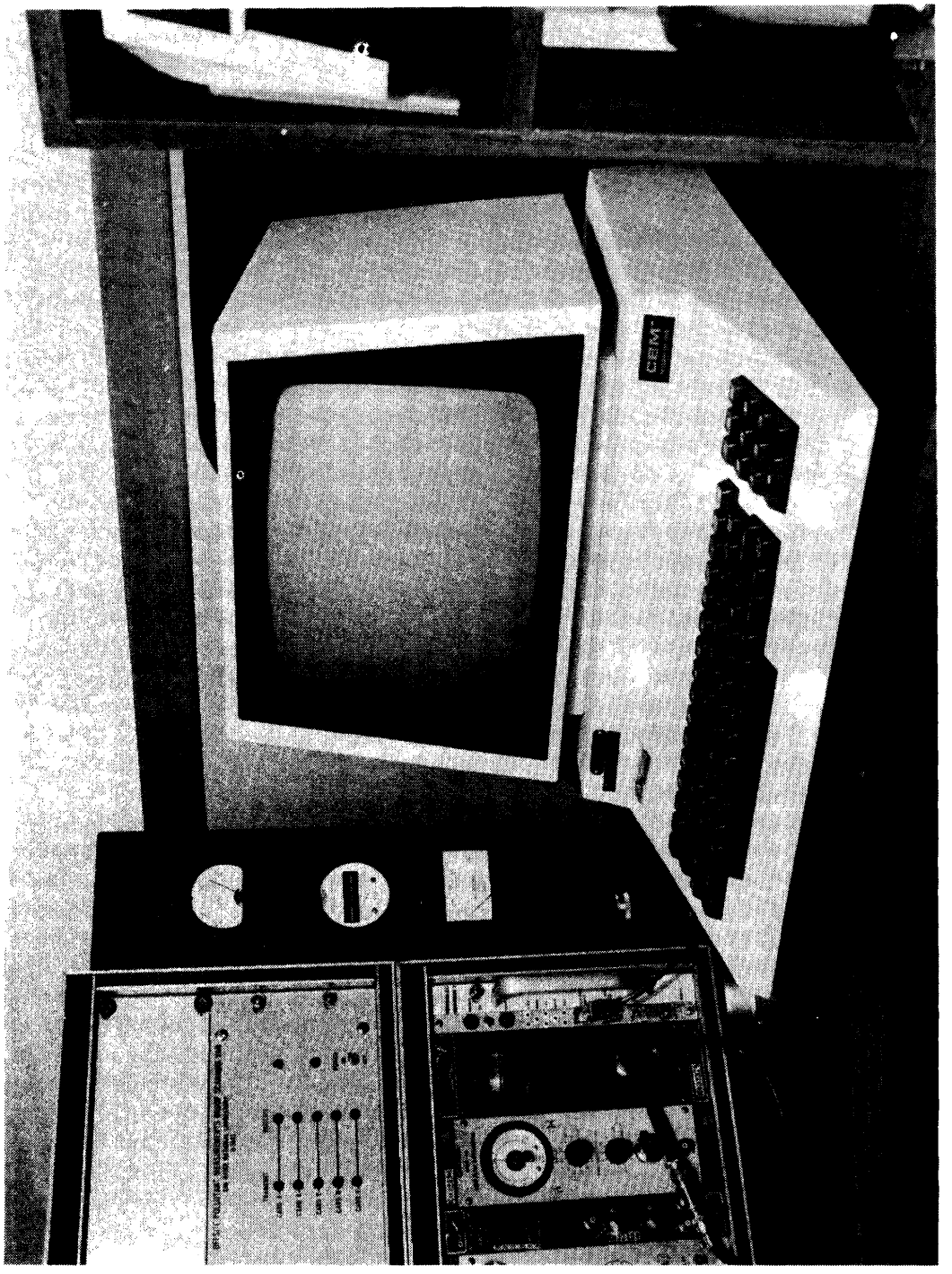
SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.3. Mobile gamma scanning operator console area.



SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.4. CBM Model 8032 computer.



SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.5. CBM Model 8050 disk drive and MFE recorder.

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.6. Interface unit and multichannel analyzer.

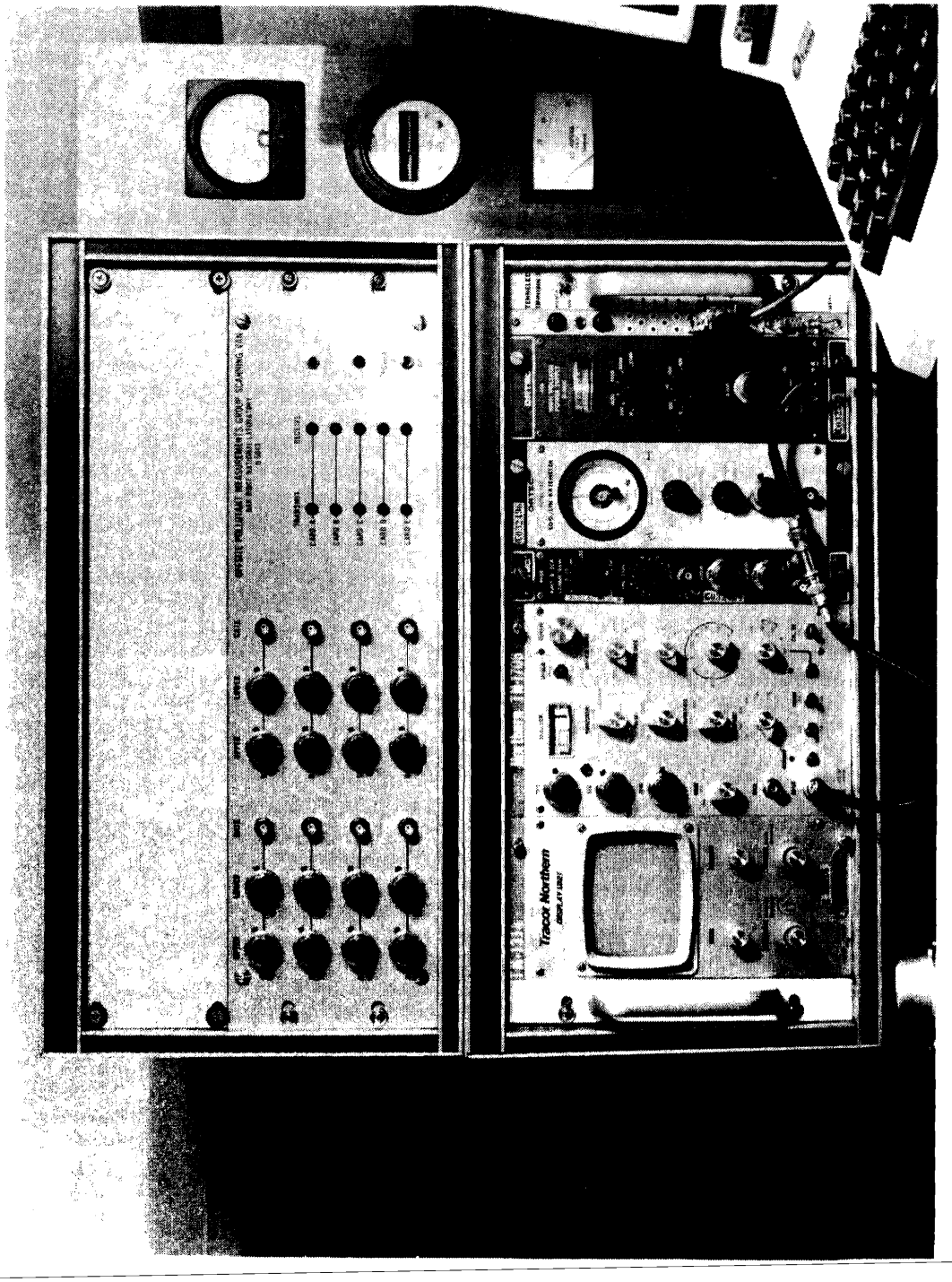
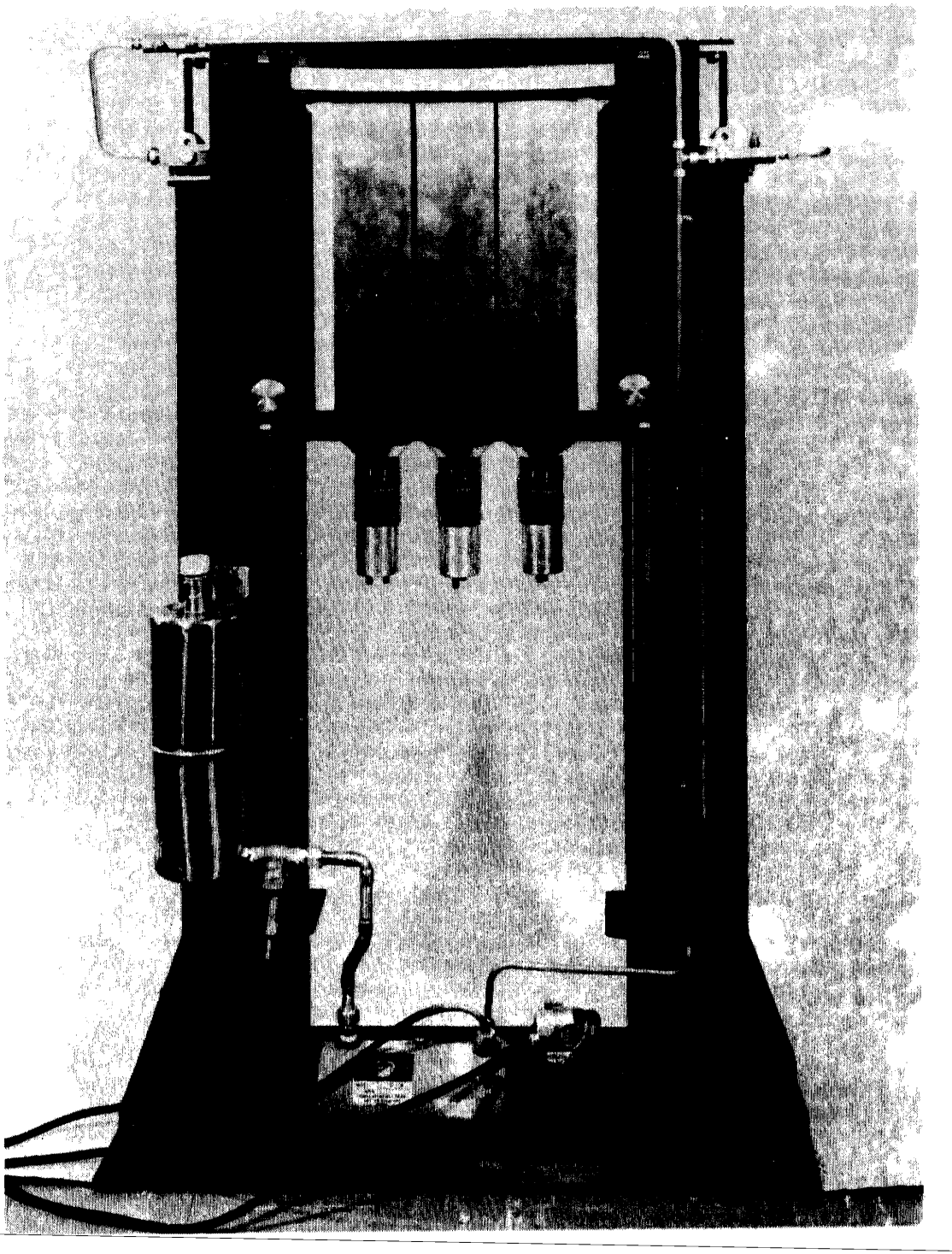


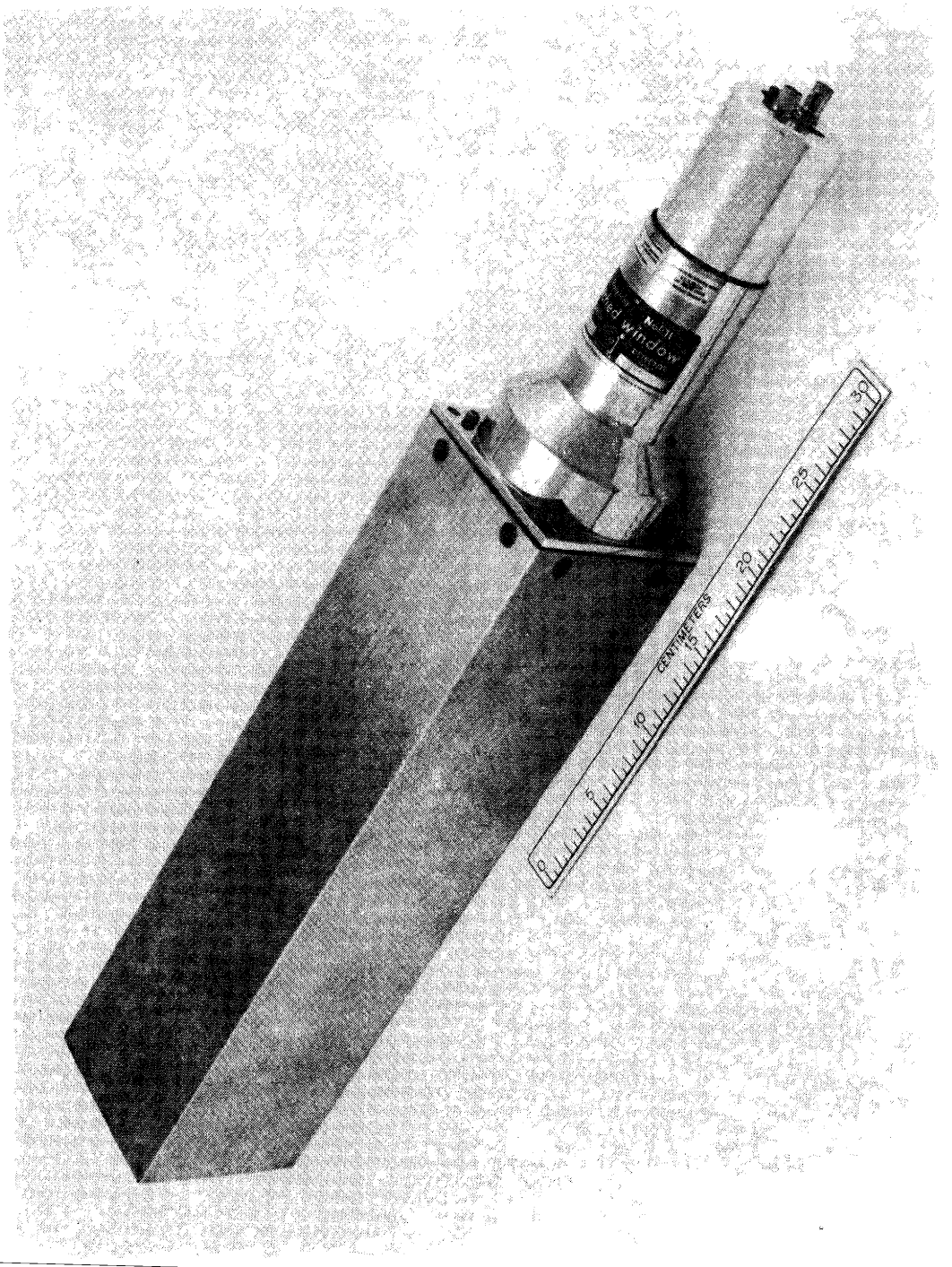
Exhibit 12.7. Detectors mounted on carriage/hydraulic system.



SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.8. Close-up view of detectors on carriage.

Exhibit 12.9. Close-up view of polyscin NaI(Tl) detector assembly.



SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.10. System description for the updated ORNL-RASA scanning van.

BASIC SYSTEM DESCRIPTION

The gamma-ray detection system now employed in the ORNL-RASA scanning van consists of three 4 x 4 x 16-in. NaI(Tl) Polyscin log crystals, each having an integral 3.5-in. photomultiplier tube. The crystals are housed in a lead-shielded steel frame to provide a 12 by 16-in. detector surface area for acceptance of gamma rays through one side of the survey van. The detector and shield height can be changed by use of a hydraulic lift mechanism to optimize the detector field-of-view.

The detector output is transferred to a computer-controlled interface designed and fabricated at ORNL. This unit provides for continuous analysis of data inputs for correlation of system location with count rate information. Six separate energy regions-of-interest are analyzed and a ^{226}Ra-specific algorithm is employed to identify locations containing residual radium-bearing materials. Data on other naturally occurring radionuclides (such as K-40 and ^{232}Th) are obtained for comparison as part of the analysis. Multichannel analysis capabilities are included in the system for additional qualitative radionuclide identification.

The system is operator-controlled through keyboard instructions to an on-board minicomputer. Data output is provided on the computer video screen, dual strip chart recorders, and a printer. Data storage is provided by a dual floppy disk system.

DATA ANALYSIS TECHNIQUE

The algorithm employed for continuous analysis of the scan data was developed from techniques used for aerial scanning of radiologically contaminated areas.[1] In this analysis, comparison is made between the observed count rates arising from naturally occurring radionuclides (^{232}Th daughters in our case) and residual radioactive materials (^{226}Ra daughters). Where the observed ratio of these count rates (Ra/Th) is determined to be significantly different from a normal background range, the location is identified as a radiation anomaly.

In the ORNL system, three regions-of-interest for ^{226}Ra are continuously analyzed (the 609 keV, 1120 keV, and 1764 keV energy peaks of Bi-214) and one for ^{232}Th (the 2614 keV energy peak of Tl-208). Based on the observed count rates in these energy regions in a background area, an average background radium-to-thorium ratio (R) can be determined as follows:

[1]Bristow, Q., *The Application of Airborne Gamma-ray Spectrometry in the Search for Radioactive Debris from the Russian Satellite Cosmos 954 (Operation Morning Light)*, Current Research, Part B, Geol. Survey of Canada, Paper 78-1B, pp. 151-162, 1978.

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.10. (Continued).

$$\bar{R} = Ra/Th = \frac{(609\ keV + 1120\ keV + 1764\ keV)}{(2614\ keV)}.$$

Associated with this average ratio is a standard deviation that is dependent upon the variation of the individual Ra and Th components.

$$\sigma\bar{R} = \bar{R}\left[\left(\frac{Th}{\bar{X}_{Th}}\right)^2 + \left(\frac{Ra}{\bar{X}_{Ra}}\right)^2\right]^{1/2},$$

where

$\sigma_{\bar{R}}$ = standard deviation of the Ra/Th ratio,

$\bar{R}$ = average Ra/Th ratio in background area,

σTh = standard deviation of the Th energy region (2614 keV),

$\bar{X}_{Th}$ = average Th count rate in background area,

$\bar{X}_{Ra}$ = average Ra count rate in background area,

σ_{Ra} = standard deviation of the Ra energy region (609 keV + 1120 keV + 1764 keV).

Thus, for any area to be scanned, some Ra/Th ratio can be computed $\bar{R} \pm k\sigma_{\bar{R}}$ (where k is the specified 2-sided confidence level) that can be used for comparison with the scan data obtained for each street.

In identifying locations containing residual ^{226}Ra-bearing materials, the ORNL system uses three criteria (hit criteria), all based on the observed background Ra and Th count rates and the computed Ra/Th ratio. The first criterion that must be met involves the determination of a minimum count rate in the Ra energy regions that results in a detectable change in the observed Ra/Th ratio. The mathematical expression for this criterion is as follows (adapted from the reference cited above):

$$C_m = 2K\ [\bar{X}_{Ra}(\bar{R} + 1)]^{1/2} + k^2,$$

Exhibit 12.10. (Continued).

where

C_m = minimum Ra count rate above background,

k = specified 2-sided confidence level,

$\bar{X}_{Ra}$ = average Ra count rate in background area,

$\bar{R}$ = average Ra/Th ratio in background area.

For a detected count rate to pass this first hit criterion, the total count rate in the three Ra energy windows must exceed $\bar{X}_{Ra} + C_m$.

The second and third hit criteria, either of which must be met before a location is considered an anomaly, are based on comparison of the observed Ra/Th ratio with the computed background ratio. In the second criterion, the observed and background ratios are directly compared, and if the observed Ra/Th > $\bar{R} = k\sigma_R$, the location is considered to have exceeded the criterion and the analysis moves to the third criterion. In the third criterion (called the difference techniques), a mathematical difference is computed.

$$\text{difference} = \text{observed Ra} - [\text{observed Th } (\bar{R} + k\sigma_R)].$$

When this difference is positive, the observed count rate is considered above the criterion.

The second and third criteria, although based on the same background ratio, provide different degrees of sensitivity, depending on the magnitude of the observed count rates in the energy windows. Their combined use provides for a reduction in the incidence of false hits, such as the identification of properties containing radiation anomalies when they actually do not and identification of properties as having ^{226}Ra-bearing material (tailings) when they only contain natural material (e.g., shale).

SCANNING METHOD

Because the data analysis method employed on the ORNL-RASA van is based on computations involving background count rates in various energy regions, these background levels must first be established. To establish background, the city to be scanned is divided into small areas (approximately ten city blocks on a side) for which an associated background level will be determined.

In each of these areas, a scan is made at normal driving speed traversing at least 75% of the streets included in the section. At the end of this scan, the average count rates and associated standard deviation for each of the energy windows are computed, the average Ra/Th ratio and its standard deviation determined, and the data stored for later use.

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.10. (Continued).

After the background levels for all survey areas have been established, the street-by-street scans of these areas can begin. For each street to be scanned, a storage file is opened on the floppy disk system and the file identified by the name of the street and the direction of travel. Scanning is conducted at a minimum speed (approximately 5 mph), and an alarm system alerts the driver if this minimum is exceeded. The distance between the van and the property is also maintained at a minimum (i.e., next to the curb unless obstructions such as parked cars prevent it). During the scan, the detectors are secured in the full up position (approximately 6 ft above ground surface) to maximize the field-of-view and minimize the influence of street-side obstructions.

As the scan proceeds, permanent landmarks (house numbers, cross streets) are systematically input to the computer to be stored along with the rest of the scan data for cross reference. If during the scan, a property is passed that exhibits gamma radiation levels exceeding the preset hit criteria, an alarm is sounded and special notation made on the computer video screen. This alarm continues to sound until the anomaly has been passed. At the end of the scan, the data file is closed and computer analysis of the data begins. This analysis results in the printout of a list of all anomalies identified by the scan and provides exact location information in terms of distance from the input permanent landmarks. To further define the locations and additional information, a second scan of each anomaly is performed at an even slower speed to better define the area of concern and allow for detailed description of property (i.e., house address, or if unavailable, a description of the house). If desired at this time, a detailed spectrum analysis can be undertaken utilizing the on-board multichannel analyzer system.

When one side of the street has been analyzed, the other side is scanned in the opposite direction. In addition, all accessible parking areas, alleyways, and other public thoroughfares would be scanned within the survey section. When all the scanning has been completed, the complete set of raw data for the entire surveyed area can be printed out for future reference.

DATA STORAGE

To maintain accurate and complete records of the scanning activities, the updated ORNL scanning system provides for two levels of data storage/recording. The primary data storage system is the floppy disk. This system maintains a continuous permanent record of all raw data obtained during the scan. Retrieval of this data occurs (1) at the end of each scan in the form of the computer-analyzed summary of the anomaly locations or (2) on command at a later time for a complete listing of the raw data or listing of the reduced data used in comparison with the hit criteria.

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.10. (Continued).

As a backup for the floppy disk system and for additional visual display of scanning results, a dual-channel strip-chart recorder is included. This strip-chart system provides for continuous recording of the gross count rate observed by the detectors as well as the observed Ra/Th ratio. The strip-chart unit has a printing capability to label the chart with the filename of the street being scanned and provide a systematic correlation of distance traveled with the chart response. An event marker is also used to identify the location of the permanent landmarks input by the operator into the computer for additional cross-correlation with the data printout.

To ensure that no loss of data occurs when the detector system experiences an unexpected power loss because of generator malfunction or other problem, the van has been provided with an uninterruptable battery power supply for the data handling and storage systems. In the event of a detector system shutdown, the previously stored data is adequately protected and can be retrieved without concern of data deletion.

SYSTEM VERSATILITY

The ORNL scanning van system has been optimized to look for locations containing ^{226}Ra-bearing materials. However, if desired, system modifications could be made to allow for the analysis of other radionuclides. For instance, with the current setup, one of the data channels is used for the acquisition of K-40 data. Although these data are not used in the algorithm for ^{226}Ra analysis, it could be used in determining the presence of highly fertilized fields.

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.11. Scan program and useful computer commands.

General

Command	Function
Place program disk in Drive 0 and press SHIFT and RUN/STOP keys	This loads the DOS program. Once the DOS has been loaded, all communications with the disk can be obtained by the use of the following commands
>$D	Will display the directory of the disk drive indicated by D. D must be either 0 or 1
>iD	Will initialize the disk drive D. (D is either 0 or 1)
↑Program Name	Will load and run the program (for scanning enter ↑scan)
/Program Name	Will load but will not run the program
>nD - name, 00	Will format a disk in Drive D. The name can be no more than 24 characters and must be followed by a two-digit identification number
>c1 = 0	Will copy the files on drive 0 to drive 1
>and press RETURN key	Will print the error message and clear the error channel
Press EXIT[a] key	Will get the computer out of any scan program mode and return to the program mode directory
Load "$D", 8	Loads the directory from drive D
Open 4,4 - CMD4 - LIST	Opens the communication channel to the printer and lists the directory
Print #4 - Close 4	Closes the communication channel to the printer
To print disk directory[b]	

[a]The EXIT key is the CLR-HOME key on the computer keyboard.
[b]This will erase all programs in the computer except the DOS program.

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.11. (Continued).

```
20 rem scanning van program 6/2/82 msb
40 poke 59468,12
60 open4,4,7:print#4:close4
80 print"▒"spc(10)"input your name ";:input n$
100 printspc(10)"input date (3/4/82)";:input n1$
120 poke 59468,14:dim d$(39)
140 gosub2720
160 open5,6,6:print#5,chr$(131);:close5
161 print"▒▒▒▒▒▒";spc(16);"▒APPROPRIATE BACKGROUND DATA MUST BE ENTERED"
162 print spc(17);"▒PRIOR TO ACCESSING ANY OTHER PROGRAM MODE"
180 goto4280
200 print"▒▒▒"spc(22)"ORNL RASCA SCANNING VAN";print"▒"
220 print spc(25);"▒PROGRAM DIRECTORY▒";"▒▒"
240 print spc(10);"▒s▒can: records all street survey data (scan data)
260 print spc(10);"▒b▒ackground: define background for area to be scanned"
280 print spc(10);"▒c▒alibration: used for system checkout"
300 print spc(10);"▒d▒ata dump: prints all stored raw data"
320 print spc(10);"▒f▒ile list: prints data above hit criteria"
340 print spc(10);"▒i▒dentification: pinpoint anomaly location▒▒"
360 d=0:d$=""
380 printspc(10)"ENTER ONLY THE FIRST LETTER OF THE DESIRED PROGRAM MODE";
385 print chr$(166)
400 get i$:if i$="" goto560
420 if i$="c" goto6240
440 if i$="b" goto4240
460 if i$="s" goto640
480 if i$="i" goto7160
500 if i$="d" goto8020
520 if i$="+" goto10220
540 i$="":goto200
560 for i=0 to 100:next i
580 printspc(10)"▒ENTER ONLY THE FIRST LETTER OF THE DESIRED PROGRAM MODE
600 for i=0 to 100:next i
620 print"▒";:goto380
640 rem scan program
660 print"▒"spc(30)"▒SCAN PROGRAM▒"
680 print"▒▒"spc(5)"The file name should be the primary road to be scanned"
700 print" and the direction of travel should be the last character in the"
720 print" file name.The file name can be no more than 16 characters."
740 print"▒▒"spc(30)"▒example▒"
760 print spc(25)"chartiers sw n"
780 print spc(25)"▒road         ▒direction▒"
800 print"Input house numbers systematically and all cross streets."
820 print"▒ Use the exit key to close the scan file and return to the program"
840 print"directory.";:print
860 c$=i$:i$="":d=0
880 printspc(25)"INPUT FILE NAME ";
900 let l=16 :gosub2160
920 if a$=chr$(19) goto200
930 gosub 2760
933 for i=0 to 800:next i
935 gosub 2720
940 s$=i$:i$="":l=1
960 print"▒  TOTAL      TOT Ra      Ra/Th      POS"
980 print"DISTANCE    COUNTS      RATIO      DIFF"
1000 print tab(0);chr$(15);"▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒▒";tab(79);chr$(143);"▒"
1020 open5,6,6:print#5,chr$(130);:for i=0 to 100:next i
1040 print#5,s$;:close5
```

Exhibit 12.11. (Continued).

```
1060 open2,8,2,"1:"+z$+",seq,write"
1080 print#2,t1;chr$(13);t2;chr$(13);
1100 print#2,n$;chr$(13);n1$;chr$(13);
1110 d=0
1120 rem loop
1140 for i=0 to 200:next i
1160 gosub2720
1180 gosub2820
1200 open 5,6,6:if l=20 then print#5,d$;:l=0
1220 l=l+1
1240 if r9<t1 goto1340
1260 if r3=>t2 goto1300
1280 if r1<0 goto1340
1300 b1=1:if r1>0 then r1$="+"
1320 r=r-50:goto1380
1340 if r1<0 then r1$="-"
1360 b1=0
1380 if (a1*0.258)>10 then b3=1:goto1420
1400 b3=0
1420 if b3>b4 then print#5,chr$(135);:goto1460
1440 if b3<b4 then print#5,chr$(134);
1460 if b1>b2 then print#5,chr$(133);:r2$="*":goto1500
1480 if b1<b2 then print#5,chr$(132);:r2$=""
1500 for i=0to100:next i:print#5,chr$(136);
1520 if r<0 then r=0
1540 g$=a1$+a2$+a3$+a4$+a5$+a6$+a7$+a8$
1560 print#2,g$;chr$(13);
1570 print"                                                    ";print"";
1580 print spc(8-len(d$));d$;spc(10-len(r9$));r9$;spc(10-len(r3$));r3$;
1600 print"        "r1$"     "r2$
1620 print b$;""
1640 a$="":print#5,chr$(143);chr$(r);
1660 close 5:b2=b1:b4=b3
1680 get a$:if a$="" goto1120
1700 if a$=chr$(13) goto1760
1720 if a$=chr$(13) goto1900
1730 if a$=chr$(20)goto 1840
1740 b$=b$+a$:goto1680
1760 print#2,b$;chr$(13);
1780 open5,6,6:print#5,chr$(137);:close 5
1800 print b$:b$="":goto1120
1820 d=0:b$="":goto1120
1840 if len(b$)=1 then b$=""
1860 if b$=""goto1680
1880 b$=left$(b$,len(b$)-1):goto1680
1900 b$="end":print"SSS"
1920 print#2,b$;chr$(13);
1940 b$="":close 2
1960 open5,6,6:print#5,chr$(131);
1980 print#5,chr$(132);chr$(134);:close5
2000 open 2,8,8,"1:"+z$+",seq,read"
2020 sys 53849
2040 input#2,t1:print t1
2060 input#2,t2:print t2
2080 input#2,n$:print n$
2100 input#2,n1$:print n1$
2120 gosub3040
2140 goto200
2160 rem input nosd name******
2180 print chr$(166)"";
```

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.11. (Continued).

```
2200 get a$ :if a$<>"" goto2300
2220 for i=0 to 50:next i
2240 print" ";
2260 for i=0 to 50:next i
2280 goto2160
2300 if a$=chr$(13) goto2620
2320 if a$=chr$(19) goto2620
2340 if a$=chr$(34) goto2200
2360 if s$="b" goto2420
2380 if a$=":"ora$="=" goto2200
2400 if a$="," goto2200
2420 if a$<>chr$(20) goto2520
2440 if i$="" goto2200
2460 if len(i$)=1 then i$="" :goto2500
2480 i$=left$(i$,len(i$)-1)
2500 goto2600
2520 if a$<" " goto2200
2540 if a$>"z"anda$<"{" goto2200
2560 if len(i$)=l goto2200
2580 i$=i$+a$
2600 printa$"_";:goto2200
2620 print" "; :s$="" :return
2640 rem input from keyboard
2660 get i$ :if i$="" goto2660
2680 if i$=r$ then run
2700 return
2720 rem input 8 channel data******
2740 open6,6,1:open7,6,2
2760 input#6,a1$,a2$,a3$,a4$
2780 input#7,a5$,a6$,a7$,a8$
2800 close6:close7:return
2820 rem cal ratio @ hit******
2840 a1=val(a1$):a2=val(a2$):a3=val(a3$):a4=val(a4$)
2860 a5=val(a5$):a6=val(a6$):a7=val(a7$):a8=val(a8$)
2880 d=d+a1:d$=str$(int(d*.258))
2900 r1=int((a3+a5+a7)-(a8*t2))
2920 r3=int(((a3+a5+a7)/a8)+0.5):r3$=str$(r3)
2940 g$=a1$+a2$+a3$+a4$+a5$+a6$+a7$+a8$
2960 r6=r5:r5=r4:r4=255-r3*4
2980 r9=a3+a5+a7:r9$=str$(r9)
3000 r=int((r4+r5+r6)/3)
3020 return
3040 rem data list*******
3060 open4,4:l=0:d=0
3080 print#4,chr$(1);"SCAN FILE NAME--";s$:chr$(13);chr$(13);"g"
3100 print#4,spc(25);"TOTAL Ra COUNT HIT "+t1
3120 print#4,spc(25);"RATIO HIT           "+t2
3140 print#4,chr$(13);
3160 gosub3580
3180 if g$="end"goto200
3200 if x=0 goto3160
3220 l=l+1:if l=1 then gosub4020
3240 r3$=str$(r3):r1$=str$(r1):r9$=str$(r9)
3260 print#4,spc(6-len(a9$));a9$:spc(21-len(b$));b$;
3280 print#4,spc(7-len(d1$));d1$;spc(10-len(r9$));r9$;spc(7-len(r3$));r3$;
3300 print#4,spc(7-len(r1$));r1$:chr$(13);
3320 a9$="":b$=""
3340 for i=1 to 3
3360 gosub3580:rem input data
3380 if g$="end"goto200
```

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.11. (Continued).

```
3400 if len(g$)<30 then print#4,spc(6-len(a9$));a9$;spc(21-len(b$));b$;
3420 if len(g$)<30 then print#4,spc(7-len(d1$));d1$;chr$(13);
3440 if x=1 goto3520
3460 next i
3480 print#4,"=============================================================="
3500 goto3160
3520 print#4,spc(34-len(d1$));d1$;spc(10-len(r9$));r9$;spc(7-len(r3$));r3$;
3540 print#4,spc(7-len(r1$));r1$;chr$(13);
3560 goto3340
3580 input#2,g$:if g$=""goto3580
3600 print g$
3620 if len(g$)<30 goto3960
3640 a1$=mid$(g$,3,6):a2$=mid$(g$,11,6):a3$=mid$(g$,20,5):a4$=mid$(g$,28,5)
3660 a5$=mid$(g$,36,5):a6$=mid$(g$,44,5):a7$=mid$(g$,52,5):a8$=mid$(g$,60,5)
3680 a1=val(a1$):a2=val(a2$):a3=val(a3$):a4=val(a4$)
3700 a5=val(a5$):a6=val(a6$):a7=val(a7$):a8=val(a8$)
3720 if a8=0 then a8=1
3740 d=d+a1:d$=str$(int(d*.258))
3760 d1=d-a9:d1$=str$(int(d1*.258))
3780 r1=int((a3+a5+a7)-(a8*t2)):r1$=str$(r1)
3800 r3=int(((a3+a5+a7)/a8)+0.5):r3$=str$(r3)
3820 r9=a3+a5+a7:r9$=str$(r9)
3840 if r9<t1 goto3940
3860 if r3=>t2 goto3920
3880 if r1>0 goto3920
3900 goto3940
3920 x=1:return
3940 x=0:return
3960 if g$="end" goto4140
3980 b$=g$:a9$=d$:a9=int(d)
4000 x=0:return
4020 print#4," TOTAL              STREET       NET    TOT Ra   Ra/Th   POS"
4040 print#4,"DISTANCE            NUMBER     DISTANCE COUNTS   RATIO   DIFF";
4060 print#4,spc(3)"REMARKS/LOCATION"
4080 print#4,"-------------------------------------------------------------";
4100 print#4,"----------------"
4120 return
4140 if l=0 then print#4,spc(24);chr$(1)"NO ANOMALIES"
4160 print#4:print#4:print#4,"RRRRRRRRRRRRRRRRRRRRRRR      ";n1$""
4180 print#4,"     "n$:print#4,chr$(12)
4200 close 2:close 4:b$="":d=0
4220 return
4240 rem background program******
4260 print "  "spc(30)"BACKGROUND PROGRAM"
4280 print"   "
4300 printspc(10)"BACKGROUND DATA FOR AREA TO BE SCANNED CAN BE OBTAINED FROM"
4320 print"  "spc(15)"new file: background scan of area"
4340 print spc(15)"old file: data from previous background file"
4360 print"    "
4380 printspc(10)"ENTER ONLY THE FIRST LETTER OF THE DESIRED PROGRAM MODE";
4385 print chr$(166)
4400 get i$:if i$="" goto4500
4420 if i$="n" goto4600
4440 if i$="o" goto5860
4460 if i$=chr$(13) goto200
4480 i$="":goto4380
4500 for i=0 to 100:next i
4520 print"";
4540 printspc(10)"ENTER ONLY THE FIRST LETTER OF THE DESIRED PROGRAM MODE
4550 gosub 2720
```

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.11. (Continued).

```
4560 for i=0 to 100:next i
4580 print"■":goto4880
4600 t=0:i$=""
4620 print"■■■■"spc(25)"BACKGROUND SCAN"
4640 print"■■■"spc(10)"Scan of area should be obtained at normal driving speed"
4660 print"■■"spc(10)"Max length of file name is 16 characters"
4680 print"■■"spc(10)"Use the exit key to close the background file and"
4700 print spc(8)"return to the program directory.":print"■■■"
4720 print spc(20)"INPUT BACKGROUND FILE NAME  ":
4740 let l=16 :gosub2160
4760 if a$=chr$(19) goto200
4780 s$=i$:i$=""
4800 print"■  TOTAL      TOT Ra      Ra/Th"
4820 print"DISTANCE    COUNTS      RATIO"
4840 print tab(0);chr$(15);"■■■■■■■■■■■■■■■■■■■■■■■■";tab(79);chr$(143);"■"
4845 gosub 2720
4847 for i=0 to 800:next i
4850 gosub 2720
4860 open2,8,2,"1:"+s$+",seq,write"
4880 for i=0 to 400:next i
4900 gosub2720
4920 t=t+1:a$=""
4940 gosub2820
4960 m1=a2+m1:m2=m2+(a2-a3):m3=a3+m3:m4=m4+a4+a5+a7
4980 m5=m5+a8:m6=m6+a6
5000 g$=a1$+a2$+a3$+a4$+a5$+a6$+a7$+a8$
5020 print#2,g$:chr$(13);
5040 r9$=str$(r9):r3$=str$(r3)
5060 print spc(8-len(d$));d$;spc(10-len(r9$));r9$;spc(10-len(r3$));r3$
5080 get a$:if a$="" goto4880
5100 if a$=chr$(19) goto5140
5120 goto4880
5140 b$="end":print#2,b$;chr$(13);
5160 gosub5680
5180 b$="":close 2
5200 print"■■■"
5220 open2,8,2,"1:"+s$+",seq,read"
5240 input#2,g$
5260 print g$
5280 if g$="end" goto5320
5300 g$="":goto5240
5320 close 2:close 5:print"■■"
5340 open4,4:print#4,chr$(1);"BACKGROUND FILE NAME--■";s$;chr$(13)"■"
5360 m1$=str$(int(m1+0.5)):b1$=str$(int(b1+0.5))
5380 m4$=str$(int(m4+0.5)):m5$=str$(int(m5+0.5)):m6$=str$(int(m6+0.5))
5400 m9$=str$(int(m9+0.5)):b4$=str$(int(b4+0.5)):b5$=str$(int(b5+0.5))
5420 b6$=str$(int(b6+0.5)):r3$=str$(int(r3+0.5))
5440 print#4,spc(16);"MEAN";spc(6);"STD.DEV."
5460 print#4,spc(26);"1 SIGMA"
5480 print#4,"-----------------------------------"
5500 print#4,"GROSS COUNTS";spc(8-len(m1$));m1$;spc(10-len(b1$));b1$
5520 print#4,"TOTAL Ra"spc(12-len(m4$));m4$;spc(10-len(b4$));b4$
5540 print#4,"Th"spc(18-len(m5$));m5$;spc(10-len(b5$));b5$
5560 print#4,"K";spc(19-len(m6$));m6$;spc(10-len(b6$));b6$
5580 print#4,"Ra/Th";spc(15-len(m9$));m9$;spc(10-len(r3$));r3$
5620 t2=int(m9+(2*r3))
5640 t1=int((2*(sqr(m4*(m9+1))+1))+m4)
5643 print#4,"■■■■"
5645 print#4,"HIT CRITERIA"
5650 print#4,"TOTAL Ra COUNTS   "+1
```

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.11. (Continued).

```
5655 print#4,"RATIO              "t2
5656 print#4,chr$(12):close4
5660 goto200
5680 rem cal mean @ std. dev.*******
5700 m1=m1/t:m2=m2/t:m3=m3/t:m4=m4/t
5720 m5=m5/t:m6=m6/t
5740 b1=sqr(m1):b2=sqr(m2):b3=sqr(m3):b4=sqr(m4)
5760 b5=sqr(m5):b6=sqr(m6)
5780 r3=sqr((b4/m4)*(b4/m4)+(b5/m5)*(b5/m5))
5800 m7=m2/m3:m8=m4/m6:m9=m4/m5
5820 r3=int(m9*sqr((b5/m5)*(b5/m5)+(b4/m4)*(b4/m4)))
5840 return
5860 rem input background data from old file******
5880 print"▒":l=10:i$=""
5900 print spc(20)"▒INPUT BACKGROUND DATA FROM OLD FILE▒"
5920 print spc(10)"INPUT TOTAL Ra COUNTS (MEAN)";
5940 gosub2160
5960 m4=val(i$):i$=""
5980 print:print spc(10)"INPUT Ra/Th RATIO (MEAN)";
6000 gosub2160
6020 m9=val(i$):i$=""
6040 print:print spc(10)"INPUT Ra/Th RATIO (STD. DEV.)";
6060 gosub2160
6080 r3=val(i$):i$=""
6100 t2=int(m9+(2*r3))
6120 t1=int((2*(sqr(m4*(m9+1)))+1))+m4)
6140 print:print spc(10)"▒▒▒NEW HIT CRITERIA"
6160 print spc(10)"TOTAL Ra"t1
6180 print spc(10)"RATIO"t2
6200 for i=0 to 2000:next i
6220 goto200
6240 rem calibration program******
6260 print"▒";spc(25)"▒CALIBRATION/INSTRUMENT SETTINGS▒"
6280 print spc(25)"▒PHOTOPEAK CHANNEL SETTINGS"
6300 print spc(25)"Cs-137(0.661MeV) channel 111"
6320 print spc(25)"Co-60(1.170MeV) channel 192"
6340 print spc(25)"Co-60(1.330MeV) channel 217"
6360 print spc(25)"Tl-208(2.614MeV) channel 424"
6380 print spc(30)"▒▒▒WINDOW DISCRIMINATORS"
6400 print"ROI"spc(20)"UPPER   CHANNEL#"spc(10)"LOWER   CHANNEL#":print
6420 print"A1 distance"spc(14)"10.0"spc(21)"1.50"
6440 print"A2 gross counts"spc(10)"7.00"spc(21)"0.06"
6460 print"A3 0.609MeV"spc(14)"1.88      120"spc(13)"1.35        90"
6480 print"A4 0.609MeV"spc(14)"1.86      120"spc(13)"1.31        90"
6500 print"B1 1.120MeV"spc(14)"3.06      200"spc(13)"2.66       170"
6520 print"B2 1.460MeV"spc(14)"4.12      260"spc(13)"3.33       215"
6540 print"B3 1.764MeV"spc(14)"4.81      305"spc(13)"3.75       260"
6560 print"B4 2.614MeV"spc(14)"8.00      500"spc(13)"5.76       382▒▒▒"
6580 print spc(20)"DEPRESS ANY KEY TO START THE PROGRAM"chr$(168)
6600 get i$:if i$="" goto6660
6620 if i$=chr$(19) goto200
6640 goto6740
6660 for i=0 to 50:next i
6680 print"▒"spc(20)"DEPRESS ANY KEY TO START THE PROGRAM      ";"▒"
6700 for i=0 to 50:next i
6710 gosub 2720
6713 for i=0 to 800:next i
6715 gosub 2720
6720 for i=0 to 400:next i
6725 goto6580
```

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.11. (Continued).

```
6740 a9=0:x$="  ":t=1
6760 gosub2720
6770 gosub 2820
6780 print"dist";"        ";"gross";"        ";"Ra"
6800 print"pulse";"       ";"counts";"    ";"0.609MeV"
6820 printspc(8-len(d$));d$;x$;a2$;x$;a3$:print
6840 print"   Ra          K          Ra          Th"
6860 print"1.120MeV  1.460MeV  1.764MeV  2.614MeV"
6880 printa5$;x$;a6$;x$;a7$;x$;a8$
6900 print:print:print
6920 print:print"10 second count 0.609MeV"
6940 print spc(14-len(a9$));a9$
6950 print:print"average count rate="m4
6960 a3=val(a3$)
7000 a9=a3+a9
7020 if t=10 goto7110
7040 t=t+1
7060 get i$:if i$="" goto6760
7080 if i$=chr$(19) goto200
7090 if i$=chr$(48) then d=0
7100 i$="":goto6760
7110 m3=m2:m2=m1:m1=a9
7115 m4=int((m3+m2+m1)/3)
7120 t=0:a9$=str$(a9):a9=0
7140 goto7040
7160 rem identify program*******
7180 print"[redacted]"spc(27)"[redacted]IDENTIFICATION PROGRAM[redacted]"
7200 print"THIS PROGRAM IS TO PINPOINT THE EXACT LOCATION OF THE ANOMALIES."
7220 print"The data is not stored in this program.If a permanent record is"
7240 print"needed then return to the SCAN program[redacted]"
7260 print spc(10)"TO RESET DISTANCE,DEPRESS 0"
7280 print spc(10)"TO EXIT PROGRAM.DEPRESS EXIT KEY[redacted]"
7300 print spc(10)"DEPRESS ANY KEY TO START THE PROGRAM"chr$(166)
7320 get i$:if i$="" goto7380
7340 if i$=chr$(19) goto200
7360 goto7460
7380 for i=0 to 50:next i
7400 print"[redacted]"spc(10)"DEPRESS ANY KEY TO START THE PROGRAM     ";"[redacted]"
7420 for i=0 to 50:next i
7440 goto7300
7460 print"[redacted]  TOTAL      TOT Ra      Ra/Th      POS"
7480 print"DISTANCE    COUNTS      RATIO      DIFF"
7500 print tab(0);chr$(15);"[redacted]";tab(79);chr$(143);"[redacted]"
7510 gosub 2720
7513 for i=0 to 800:next i
7515 gosub 2720
7520 open 5,6,6
7540 for i=0 to 400:next i
7560 gosub2720
7580 gosub2820
7600 if r9<t1 goto7700
7620 if r3<t2 goto7700
7640 if r1<0 goto7700
7660 print#5,chr$(133);:r2$="*"
7680 r1$="+":goto7760
7700 if r1<0 then r1$="-"
7720 if r1>0 then r1$="+"
7740 print#5,chr$(132);:r2$=""
7760 if r<0 then r=0
7780 close 5
```

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.11. (Continued).

```
7800 r9$=str$(r9)
7840 print spc(8-len(d$));d$;spc(10-len(r9$));r9$;spc(10-len(r3$));r3$;
7860 print"        "r1$"     "r2$
7880 i$=""
7900 get i$:if i$="" goto7520
7920 if i$=chr$(19) goto7980
7940 if i$="0" then d=0
7960 i$="":goto7520
7980 print"SS"
8000 open 5,6,6:print#5,chr$(132):close5:goto200
8020 rem data dump program******
8040 print"S";spc(27)"QDATA DUMP PROGRAMQQ"
8060 gosub9160
8080 gosub9780
8100 if a$=chr$(19) goto200
8120 if a1$="" goto9060
8140 gosub8200
8160 gosub9800
8180 goto8100
8200 a=val(a1$):d=0
8220 print"S"
8240 open4,4:print#4,chr$(1);"FILE NAME--Q";d$(a);chr$(13);chr$(13)"Q"
8260 print#4,chr$(13);chr$(13)
8280 print"    TOTAL                    Ra          Ra   ";
8300 print#4,"    TOTAL                    Ra          Ra   ";
8320 print"     K          Ra          Th   "
8340 print#4,"     K          Ra          Th   "
8360 print"  DISTANCE     GROSS  0.609MeV   1.120MeV";
8380 print#4,"  DISTANCE     GROSS  0.609MeV   1.120MeV";
8400 print"  1.460MeV  1.764MeV  2.614MeV"
8420 print#4,"  1.460MeV  1.764MeV  2.614MeV"
8440 print"   (feet)       (cps)     (cps)       (cps) ";
8460 print#4,"   (feet)       (cps)     (cps)       (cps) ";
8480 print"   (cps)       (cps)       (cps)  "
8500 print#4,"   (cps)       (cps)       (cps)  "
8520 print tab(0);chr$(15);"CCCCCCCCCCCCCCCCCCCCCCCC";tab(79);chr$(143)
8540 print"S"
8560 open 2,8,8,"1:"+d$(a)+",seq,read"
8580 input#2,g$
8600 if g$=""goto8580
8620 if len(g$)<20 goto8980
8640 a1$=mid$(g$,3,6):a2$=mid$(g$,11,6):a3$=mid$(g$,20,5):a4$=mid$(g$,28,5)
8660 a5$=mid$(g$,36,5):a6$=mid$(g$,44,5):a7$=mid$(g$,52,5):a8$=mid$(g$,60,5)
8680 a1=val(a1$):a2=val(a2$):a3=val(a3$):a4=val(a4$)
8700 a5=val(a5$):a6=val(a6$):a7=val(a7$):a8=val(a8$)
8720 if a8=0 then a8=1
8740 if g$=g1$goto9020
8760 g1$=g$
8780 d=d+a1:d$=str$(int(d*.258))
8800 a2$=str$(a2):a3$=str$(a3):a5$=str$(a5)
8820 a6$=str$(a6):a7$=str$(a7):a8$=str$(a8)
8840 print spc(10-len(d$))d$;spc(10-len(a2$))a2$;spc(8-len(a3$))a3$;
8860 print#4,spc(10-len(d$))d$;spc(10-len(a2$))a2$;spc(8-len(a3$))a3$;
8880 print spc(10-len(a5$))a5$;spc(10-len(a6$))a6$;spc(10-len(a7$))a7$;
8900 print#4,spc(10-len(a5$))a5$;spc(10-len(a6$))a6$;spc(10-len(a7$))a7$;
8920 print spc(10-len(a8$))a8$
8940 print#4,spc(10-len(a8$))a8$
8960 goto8580
8980 if g$="end" goto9020
9000 print g$:print#4,g$:goto8580
```

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.11. (Continued).

```
9020 print"":close 2
9040 print#4,chr$(19):close 4:return
9060 for a=1 to l
9080 d=0
9100 gosub8220
9120 next a
9140 goto200
9160 rem read directory******
9180 print""spc(20)"READING DIRECTORY PLEASE WAIT"
9200 open 2,8,4,"#5"
9220 print#2,"i1"
9240 open 15,8,15:x2=1:a=1
9260 print#15,"u1"4,1,39,x2
9280 get#2,a$:if a$="" then9280
9300 x1=asc(a$)
9320 if x1>77 goto9380
9340 get#2,a$:if a$="" then9340
9360 x2=asc(a$)
9380 fori=1 to 8
9400 get#2,a$:if a$="" then9400
9420 if a$<>chr$(129) goto9400
9440 l=0
9460 get #2,a$:if a$="" goto9460
9480 get #2,a$:if a$="" goto9480
9500 if a$=chr$(160) goto9620
9520 if l=18 goto9620
9540 if a$>chr$(90) then a$=""
9560 if a$<chr$(32) thena$=""
9580 b$(i)=b$(i)+a$:l=l+1
9600 goto9480
9620 if i=1 then c$=b$(1)
9640 if i=1  goto9680
9660 if b$(i)=c$ goto9760
9680 d$(a)=b$(i):a=a+1:next i
9700 for i=1 to 8:b$(i)="":next i
9720 if x1>77 goto9760
9740 goto9260
9760 close 2:close 15:return
9780 rem list directory******
9800 print"":l=a-1
9820 for i=1 to l
9840 print i"  "d$(i)::i=i+1:if d$(i)="" goto9900
9860 printtab(25)i"  "d$(i)::i=i+1:if d$(i)="" goto9900
9880 printtab(50)i"  "d$(i):if d$(i)="" goto9900
9900 next i
9920 print""
9940 print"To print a file enter the number of that file."
9960 print"To print all files depress only the return key."
9980 print"To return to the program directory depress the exit key."
10000 print"":a1$=""
10020 printspc(26)"INPUT FILE NUMBER "a1$:chr$(166)
10040 get a$:if a$="" goto10120
10060 if a$=chr$(19) goto10200
10080 if a$=chr$(13) goto10200
10100 a1$=a1$+a$
10120 for i=0 to 50:next i
10140 print spc(26)""INPUT FILE NUMBER "a1$"      "
10160 for i=0 to 50:next i
10180 goto10020
10200 return
```

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.11. (Continued).

```
10220 rem file list program******
10240 print"▯"spc(30)"▯FILE LIST PROGRAM▯▯▯▯"
10260 print spc(10)" THIS PROGRAM WILL LIST ALL DATA ABOVE HIT CRITERIA.▯▯▯"
10280 print spc(20)"▯1▯use stored hit criteria"
10300 print spc(20)"▯2▯input new hit criteria"
10320 print spc(20)"▯3▯list all data▯▯▯▯"
10340 printspc(10)"ENTER ONLY THE FIRST LETTER OF THE DESIRED PROGRAM "chr$(156

10360 get i$:if i$="" goto10480
10380 if i$="u" goto10580
10400 if i$="1" goto10900
10420 if i$="l" goto11220
10440 if i$=chr$(13) goto200
10460 i$="":goto10340
10480 for i=0 to 100:next i
10500 print"▯";
10520 printspc(10)"ENTER ONLY THE FIRST LETTER OF THE DESIRED PROGRAM
10540 for i=0 to 100:next i
10560 print"▯";:goto10340
10580 rem use stored hit criteria
10600 print"▯"spc(20)"▯LIST DATA USING STORED HIT CRITERIA▯"
10620 gosub9160
10640 gosub9780
10660 if a$=chr$(13)goto200
10680 if a$="" goto10880
10700 a=val(a1$):d=0
10720 s$=d$(a)
10740 open 2,8,8,"1:"+s$+",seq,read"
10760 input#2,g$:if g$="" goto10760
10780 t1=val(g$)
10800 input#2,g$:if g$="" goto10800
10820 t2=val(g$)
10821 input#2,n$:print n$
10822 input#2,n1$:print n1$
10840 gosub 3040
10860 goto200
10880 rem
10900 rem input new hit criteria
10920 print"▯"spc(20)"▯INPUT NEW HIT CRITERIA"
10940 gosub9160
10960 gosub9780
10980 if a$=chr$(13)goto200
11000 if a$="" goto11200
11020 a=val(a1$):d=0
11040 s$=d$(a)
11060 open 2,8,8,"1:"+d$(a)+",seq,read"
11080 print"input total Ra counts";:input t1
11100 print"input ratio hit";:input t2
11120 gosub3040
11140 gosub9800
11160 goto10880
11180 end
11200 rem
11220 rem list all data
11240 print"▯"spc(20)"▯LIST ALL DATA"
11260 gosub9160
11280 gosub9780
11300 if a$=chr$(13)goto200
11320 if a$="" goto11520
11340 a=val(a1$):d=0
11360 s$=d$(a)
11380 open 2,8,8,"1:"+s$+",seq,read"
11400 input#2,g$:if g$="" goto11400
11420 t1=0
11440 input#2,g$:if g$="" goto11440
11460 t2=0
11480 gosub9800
11500 goto11300
11520 rem
ready.
```

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.12. Gamma scanning program directory.[a]

Program	Function
Scan	Records all street survey data (scan data)
Background	Defines background for areas to be scanned
Calibration	Used for system checkout
Data Dump	Prints all stored raw data
File List	Prints data above hit criteria
Identification	Pinpoints anomaly location

[a]Enter only the first letter of the desired program mode.

Exhibit 12.13. Calibration/instrument settings.

CALIBRATION/INSTRUMENT SETTINGS

PHOTOPEAK CHANNEL SETTINGS
Cs-137(0.661MeV) channel 111
Co-60(1.170MeV) channel 192
Co-60(1.330MeV) channel 217
Tl-208(2.614MeV) channel 424

ROI	WINDOW DISCRIMINATORS UPPER	CHANNEL#	LOWER	CHANNEL#
A1 distance	10.0		1.50	
A2 gross counts	7.00		0.06	
A3 0.609MeV	1.88	120	1.35	90
A4 0.609MeV	1.86	120	1.31	90
B1 1.120MeV	3.06	200	2.66	170
B2 1.460MeV	4.12	260	3.33	215
B3 1.764MeV	4.81	305	3.75	260
B4 2.614MeV	8.00	500	5.76	382

DEPRESS ANY KEY TO START THE PROGRAM

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.14. Distance transducer calibration check data.

Date: _____

Technologist: _____

Other members: _____

_____

Tire pressure: _____ psi

Distance measurements:

1. _____ ft _____ % error

2. _____ ft _____ % error

3. _____ ft _____ % error

4. _____ ft _____ % error

5. _____ ft _____ % error

Average _____ ft _____ % error

$$\% \text{ error} = \frac{500-\text{reading}}{500} \times 100^{a}$$

[a]If % error >3% notify scanning team leader.

Exhibit 12.15. Background mode CRT display.

```
APPROPRIATE BACKGROUND DATA MUST BE ENTERED
PRIOR TO ACCESSING ANY OTHER PROGRAM MODE

BACKGROUND DATA FOR AREA TO BE SCANNED CAN BE OBTAINED FROM
     NEW FILE: BACKGROUND SCAN OF AREA
     Old file: data from previous background file

ENTER ONLY THE FIRST LETTER OF THE DESIRED PROGRAM MODE
```

Exhibit 12.16. Background scan CRT display.

```
                    BACKGROUND SCAN
Scan of area should be obtained at normal driving speed

Max length of file name is 16 characters

Use the exit key to close the background file and
return to the program directory.
```

Exhibit 12.17. Background mode printout.

BACKGROUND FILE NAME--BKGD 001

	MEAN	STD.DEV. 1 SIGMA
GROSS COUNTS	1800	42
TOTAL Ra	244	16
Th	22	5
K	79	9
Ra/Th	11	2

HIT CRITERIA

TOTAL Ra COUNTS	355
RATIO	15

Exhibit 12.18. Scan mode CRT display.

SCAN PROGRAM

The file name should be the primary road to be scanned and the direction of travel should be the last character in the file name. The file name can be no more than 16 characters.

example

chartiers av n

road direction

Input house numbers systematically and all cross streets.

Use the exit key to close the scan file and return to the program directory.

INPUT FILE NAME

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.19. Scan mode printout.

SCAN FILE NAME--300 E NORTH

TOTAL Ra COUNT HIT 505
RATIO HIT 21

TOTAL DISTANCE	STREET NUMBER	NET DISTANCE	TOT Ra COUNTS	Ra/Th RATIO	POS DIFF	REMARKS/LOCATION
586	right	392	536	21	11	
		410	555	24	72	
		414	570	34	213	
		419	565	27	124	
		423	536	36	221	
		427	534	28	135	
		433	534	21	-12	
		436	553	31	175	
		437	606	21	-3	
		441	602	35	245	
		444	527	24	65	
		448	542	39	248	
		455	522	29	144	
		459	572	27	131	
		461	584	29	164	
		564	2151	37	933	
		569	2251	45	1201	
		574	2260	43	1168	
		578	2323	52	1378	
		582	2259	37	978	
		584	2353	44	1240	
		584	2290	43	1177	
		584	2260	54	1378	
		584	2279	37	977	
		584	2312	41	1115	
		584	2333	38	1031	
		586	2257	42	1123	
		590	2131	40	1018	
		596	2088	41	1017	
		603	1853	43	950	
		610	1474	46	802	
		618	849	35	345	

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Exhibit 12.20. Identification mode CRT display.

```
                    IDENTIFICATION PROGRAM
THIS PROGRAM IS TO PINPOINT THE EXACT LOCATION OF THE ANOMALIES.
The data is not stored in this program.If a permanent record is
needed then return to the SCAN program
          TO RESET DISTANCE,DEPRESS 0
          TO EXIT PROGRAM,DEPRESS EXIT KEY
          DEPRESS ANY KEY TO START THE PROGRAM
```

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.28. Data handling and system startup.

Technologist action	CRT display	Function or comment
1. Turn on computer (switch is located on rear lower left corner)	*** COMMODORE BASIC 4.0 *** 31743 bytes free READY	
2. Turn on floppy disk system (switch is located on rear lower left corner)		Center green light will appear when system is ready
3. Insert scan program disk into the floppy disk drive 0		Disk title is "CBM Model 8050 Scan Program, 6/2/82"
4. Press SHIFT and RUN/STOP keys to load the computer/ disk support programs (DOS Support)		Disk drive 0 green light will come on while information is being transferred
	READY	DOS Support is loaded
5. Insert blank disk into Drive 1		To format the blank disk for data storage
6. Type >nl - disk name,XX		Disk name is any appropriate identifying name of not more than 16 characters. XX is a sequential number from 00 to 99, for use when multiple disks are used on site
		Disk Drive 1 green light will appear for 3 to 4 min and disappear when formatting is complete
7. Remove the disk from drive 1 and use a felt tip pen to write on the disk the name typed in Step 6 above		Disk should be removed and reinserted to ensure that the disk is registered properly when formatted

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.28. (Continued).

Technologist action	CRT display	Function or comment
8. Type ↑scan and press RETURN key	Input your name	Will load scan program from disk 0
9. Enter your name. Press RETURN key	Input date (e.g. 3/4/82)	After the log-on sequence, the program will automatically address the background program mode. If other modes are desired, go to step 11
10. Enter date. Press RETURN key		
11. Press EXIT key	CRT will display the six program modes that can be accessed (see Exhibit 12.19)	Computer will return to the program mode directory Any of the six program modes can now be accessed by typing the first letter of any program mode

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.29. Instrument calibration.

Technologist action	CRT display	Function or comment
1. Press C key.	The CRT will display the calibration/ instrument settings. See Exhibit 12.20	C is the first letter of the calibration program
2. With the CRT display as a guide, check the discriminator window settings on the interface unit. Use the values under UPPER and LOWER columns of the display for the appropriate windows (A1 through A4 and B1 through B4)		
3. Remove the 137 Cs source from the lead pig and place it in the source holder on the power strip in front of the detector support frame		
4. Push the acquire button on the MCA and observe the dead-time meter; it should be less than 10 percent		
5. Move MCA cursor to Channel 111		
6. Observe 137 Cs 0.661 MeV photopeak. If it falls in Channel 111±1, do nothing. If not, adjust the fine gain on amplifier until the peak falls within the channel range		When adjusting fine gain, always clear the acquired data to minimize confusion on the location of the photopeak
7. Record the 137 Cs photopeak channel number in the Scanning Van Calibration Log Book. Include calibrator's name, date of calibration, and location of calibration		

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.29. (Continued).

Technologist action	CRT display	Function or comment
8. Replace the 137 Cs source with a 60 Co source. Clear data. Again observe the dead time (should be ≤ 10%)		
9. Move the analyzer cursor to the center of the 1.17 MeV photopeak (approximately at Channel 192)		
10. If photopeak is ±3 channels of channel 192, go to step 11 below. If not, go back to step 3 above. If the problem cannot be resolved, go to step 21		
11. Record the 60 Co 1.17 MeV photopeak channel number in the Scanning Van Calibration Log Book		
12. Move the analyzer cursor to the center of the 1.33 MeV 60 Co photopeak (approximately channel 217)		
13. If photopeak is ±3 channels of channel 217, go to step 15. If not, return to step 3		
14. If problem cannot be resolved, go to step 21		
15. Record the 60 Co 1.33 MeV photopeak in the Scanning Van Calibration Log Book		
16. Remove the 60 Co source and store in the lead pig. Place the 208 Tl source on a bracket in front of the detectors. Observe dead time; should be less than 10%		

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.29. (Continued).

Technologist action	CRT display	Function or comment
17. Move the analyzer cursor to the center of the 2.61 MeV 208 Tl photopeak (approximately channel 424)		
18. If the center of the photopeak is ±5 channels of channel 424, go to step 19. If not, go back to step 3. If the problem cannot be resolved, go to step 21		
19. Record the photopeak channel number in the Scanning Van Calibration Log Book		
20. Return 208 Tl source to the source drawer		
21. If the analyzer cannot be calibrated to the required tolerances, the scanning team leader may contact an instrument technologist at ORNL-RASA for further adjustments or repairs		
22. Type any character on the keyboard and observe on the display unit the count rates in the appropriate discriminator regions of interest		

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.29. (Continued).

Technologist action	CRT display	Function or comment
23. Observe the "average count rate" in the Ra (609 keV) region with no source present. (Allow time for average values to stabilize approximately 40 s. Record the average background count rate in the Scanning Van Calibration Log Book		
24. Remove the 137 Cs source from the lead pig and place it at the same location as when calibrating		
25. Observe the average count rate in the Ra (609 keV) region associated with the 137 Cs source (allow approximately 40 s for count rate to stabilize). Record the average source count rate in the Scanning Van Calibration Log Book		
26. Subtract the count rate in step (23) from that in step (25) and record the net count rate in the Scanning Van Calibration Log Book. Also plot this value on the system calibration graph		

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.29. (Continued).

Technologist action	CRT display	Function or comment
27. If the net count rate is within ±5% of the previous calibration (see the log book), the detector sensitivity is considered unchanged and property scanning can begin. If the net count rate is outside the tolerance range, inform the scanning team leader, who will contact the appropriate instrument technologist for repairs		
28. Replace the 137 Cs source in the lead pig		
29. Press EXIT key to return to the program mode directory	CRT will display information shown in Exhibit 12.19	Calibration is complete, and another program mode may be accessed

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.30. Background mode operation.

Technologist action	CRT display	Function or comment
1. Press B key.	See Exhibit 12.22	This will access the background mode of the scan program
2. If a new file is to be established for background of the area, press N key. If data from a previous background file are to be used, go to step (6)	See Exhibit 12.23 Input background filename	
3. Type in filename. Press RETURN key (only when ready to accumulate data)	Accumulated background data and distance	Filename must be less than 24 characters
4. Drive the vehicle at normal driving speed to cover at least 75 % of the accessible streets to establish the background		Normal driving speed is the posted speed limit at the particular location being scanned
5. When sufficient coverage has been obtained, press EXIT key to close data acquisition	CRT will display the program directory	The computer will analyze the accumulated data and print out the results. See Exhibit 12.24
6. If a background has been established for the area to be scanned, press O (for old) key	Input total Ra counts (mean)	
7. Enter total Ra counts (mean) from a previous background measurement. Push RETURN key	Input Ra/Th Ratio (mean)	

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.30. (Continued).

Technologist action	CRT display	Function or comment
8. Enter Ra/Th ratio (mean from a previous background measurement. Push RETURN key	Input Ra/Th ratio (std dev)	
9. Enter the Ra/Th ratio standard deviation from previous background measurement. Push RETURN key	Computer will display the new hit criteria for a few seconds and return to the program directory	

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.31. Scan mode operation.

Technologist action	CRT display	Function or comment
1. Position the gamma scanning van at an identifiable permanent landmark in an area to be scanned		Landmarks can be cross streets, house number and street, etc.
2. Turn on the strip chart recorder		
3. Type S and press RETURN key	Computer will give specifications for filename and an example. See Exhibit 12.25 INPUT FILE NAME	
4. Type file name	Filename typed	Filename should be less than 24 characters
5. When ready, press RETURN key	Computer will display the accumulated data at 1-s intervals for the total distance, total Ra counts, Ra/Th ratio, and the sign of the positive difference analysis technique	Strip chart recorder will automatically turn on at this point and will display the gross counts and Ra/Th ratio. Green light on disk drive 1 will appear
6. Type start landmark and press RETURN key		Start landmark is usually a street or house number and street
Drive the scanning van at 5 mph or less as close as possible to the street curb		

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.31. (Continued).

Technologist action	CRT display	Function or comment
7. Type in landmarks and press RETURN key at regular intervals as the scan proceeds		These landmarks will serve as check points when anomalies are detected
8. After all accessible roads within the area have been scanned, press EXIT key to close the file and begin computer analysis of the data		When the computer has completed analysis of the data, the printer will print out the locations where hits occurred. It will also provide location information (distance from last identifiable landmark), appropriate count rate data in the Ra channels, the Ra/Th ratio, and the magnitude of the computer positive difference A remarks column is also provided for any comments the technologist wants to make. See Exhibit 12.26

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.32. Identification mode.

Technologist action	CRT display	Function or comment
1. Type I to access the program mode; then follow instructions on CRT - press RETURN key	See Exhibit 12.27	No data analysis is provided in this mode of scanning. Also, the distance can be reset to zero at any time by typing 0
2. Referring to the scan mode printout, find the location of the hit, and drive the van to the vicinity of the hit location		
3. Reset the distance at the positions of nearest landmark.		
4. Start scanning toward the location of hit Drive the van very slowly. Compare CRT displayed distance to that recorded on summary sheet obtained from step 8, Sect. 6.10 of this procedure	Similar information as in scan mode data	
5. Stop the vehicle at the hit location and identify the property where the hit occurred		Identification may be by house number and street or other property descriptions
6. Record the identification information under the remarks column of the summary data sheet		
7. When all hit properties have been identified, press EXIT key to end the identification mode and return to the program mode directory	Program mode directory	

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.33. Data dump mode.

Technologist action	CRT display	Function or comment
1. Type D	Filenames of all files on the disk	Computer will read the file directory on the disk in drive 1 The file names are numbered sequentially as they appear on the disk. To dump data from a single file, type the number of that file. To dump data from the entire disk, press RETURN key
2. After obtaining the desired data press EXIT key to return to the program mode directory		

SUBJECT: MOBILE GAMMA SCANNING VAN

Exhibit 12.34. File list mode.

Technologist action	CRT display	Function or comment
1. Type F.	Filenames of all files on the disk	Computer will read the file directory of the disk. The files are numbered sequentially as they appear on the disk
2. Choose the option desired as discussed at the beginning of this section		
3. Select the number assigned to the desired file, enter it, and press RETURN		
4. When the needed data are printed, press the EXIT key to return to the program mode directory		

13. FIELD MEASUREMENTS

SUBJECT: FIELD MEASUREMENTS

13. FIELD MEASUREMENTS

13.1 BACKGROUND MEASUREMENTS

13.1.1 Purpose

The purpose of this procedure is to describe the technique for obtaining background measurements and samples.

13.1.2 Applicability

This procedure applies to background measurements by ORNL-RASA personnel in support of the ORNL-RASA program.

13.1.3 References

1. Sect. 13.5, Gamma Exposure Rate Measurements (Pressurized Ion Chamber)
2. Sect. 13.6, External Gamma Radiation Measurements.
3. Sect. 14.1, Soil and Sediment Sample Collection
4. Sect. 14.2, Water Sample Collection

13.1.4 Definitions and Abbreviations

13.1.4.1 Definitions

BACKGROUND SITE. Any undisturbed area within a one- to five-mile radius of a candidate site. Background measurements outside this range can be used for regional rather than site-specific values.

UNDISTURBED. That which appears to be unaffected by radioactivity from a candidate site or other anthroprogenic sources (e.g., fertilizers).

Also see Sect. 1.5 of this manual, Terminology.

13.1.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

13.1.5 Responsibilities

13.1.5.1 Site Leader

The site leader is responsible for the implementation of this procedure.

APPROVED: _____ DATE: _____
RASA Program Manager

13.1.5.2 Instrument Technologist

The instrument technologist will make background measurements according to this procedure.

13.1.6 Procedure

13.1.6.1 Locating Background Sites

Background radiation measurement and sampling sites are located by scouting for undisturbed areas within a one- to five-mile radius from the survey site. Because the undisturbed criterion is subject to individual interpretation and judgment, each undisturbed area located must be scanned with a gamma scintillation detector to assure no anomalous radioactivity exists in the area. Refer to Sect. 13.6, External Gamma Radiation Measurements, for using the gamma scintillation detector.

13.1.6.2 Background Measurements and Sampling

After undisturbed areas have been located, measure the background gamma exposure rate and obtain the necessary samples for analysis.

External gamma exposure rate

The external gamma exposure rate is obtained using a pressurized ion chamber (PIC) detector. Follow Sect. 13.5, Gamma Exposure Rate Measurements (Pressurized Ion Chamber), for the use of the instrument.

Surface soil sample collection

For background soil sampling, only surface soil samples are obtained for analysis. Follow Sect. 14.1, Soil and Sediment Sample Collection, for requirements of surface soil sampling, labeling, packaging, and shipping.

Water sample collection

Water samples are typically not obtained from background sites. Should the collection of water samples be required, follow Sect. 14.2, Water Sample Collection, for requirements in sampling, labeling, packaging, and shipping.

13.2 ALPHA RADIATION MEASUREMENTS

13.2.1 Purpose

The purpose of this procedure is to describe the methods used to measure alpha radiation on equipment and building surfaces.

SUBJECT: FIELD MEASUREMENTS

13.2.2 Applicability

This procedure applies to radiation measurements made at RASA sites using portable scintillator and gas flow proportional counter alpha survey instruments.

13.2.3 References

1. Sect. 20.1, Calibration of Alpha Scintillators
2. Sect. 20.2, Calibration of Gas Flow Proportional Alpha Counters
3. Sect. 20.3, Calibration of Alpha Smear Counters
4. Sect. 20.8, Calibration of Beta-Gamma Smear Counters
5. Eberline Technical Manual for LIN-LOG Count Rate Meter Model PRM-4 (manual is also applicable to the PRM-4A instrument)
6. Eberline Technical Manual for LIN-LOG Gas Proportional Alpha Counter Model PAC-4G

13.2.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

13.2.5 Responsibilities

13.2.5.1 Site Leader

The site leader is responsible for implementation of this procedure.

13.2.5.2 Instrument Technologist

The instrument technologist is responsible for making and recording alpha radiation measurements at the site.

13.2.6 Procedure

Two types of instruments are used to measure alpha contamination on surfaces: a ZnS scintillator and a gas flow proportional counter. The procedure for each type of instrument is described separately.

13.2.6.1 Alpha Scintillation Survey Meter

Equipment and apparatus

1. Pulse rate meter, Model PRM-4A, 200, 2K, 20K, and 200K cpm ranges, Eberline Instrument Corporation, Santa Fe, New Mexico (see Exhibit 13.2-1)
2. Scintillation detector (Eberline AC-3 probe)
3. Five size D dry cells of any type (1.5 V nominal)
4. ORNL designed side box counter for use with low count rates
5. Portable Instrument Log Book
6. Check source (same alpha sources specified in Sect. 20.1, Calibration of Alpha Scintillators)

SUBJECT: FIELD MEASUREMENTS

Equipment preparation

1. Remove the equipment from its storage location in the mobile laboratory and check for physical damage. Report any damage to the site leader.
2. Install the batteries, if required, following procedure in paragraph A, Disassembly and Reassembly, Section IV of the Technical Manual, Maintenance (Ref. 5).
3. Connect the detector to the rate meter; hand tighten only.
4. Check the battery by switching the selector switch to BATTery check. With good battery, the black pointer should be in the green area. Replace batteries if necessary.

Operational check

Follow the procedures for operational check in Sect. 20.1, Calibration of Alpha Scintillators.

Alpha radiation measurements

1. To detect alpha radiation, turn the switch on and place the detector in contact with the surface being surveyed.

   CAUTION: The film on the probe face is very thin and can be punctured easily. Avoid placing the probe face directly on rough surfaces or other sharp objects.

2. Read the radiation intensity in cpm. When measuring high radiation levels, the black pointer is used to read up to 2K cpm. Above 2K cpm, the black pointer disappears and the red pointer appears. Watch the pointer long enough to get the average reading. For low levels, the side box counter must be used to obtain accurate values. Turn the counter on, select either a 30 s or 60 s counting time, press the reset button and allow counter to register the number of counts. Red light will go out when counting interval is completed.
3. Turn all switches off after measurements have been made. Remove the batteries if the instrument is to be stored for long periods of time. Store the instrument in its storage space in the mobile laboratory.

Documentation

Enter the measured data in the Field Data Log Book on ORNL-RASA data forms (see Exhibit 13.2-2) for alpha radiation measurements. Data entries will include site identification, date, instrument technologist initials, locations of surveyed areas, the radiation measurement results (cpm) for each area, and the instrument identification number.

Instrument limitations

For instrument limitations refer to item 5, Environmental, paragraph B, Specifications, Section I, General, of Ref. 5.

13.2.6.2 Gas Flow Proportional Counter

Equipment and apparatus

1. Gas Proportional Alpha Counter, Model PAC-4G, 500-500K cpm, Eberline Instrument Corporation, Santa Fe, New Mexico (see Exhibit 13.2-3)
2. Gas Flow Proportional Probe, Model AC-21, Eberline Instrument Corporation, Santa Fe, New Mexico
3. Check source (same sources as listed in Sect. 20.1, Calibration of Alpha Scintillators)
4. Five size D dry cells of any type (1.5 V nominal)
5. Portable Instrument Log Book
6. Gas supply, pure grade propane or equivalent

Equipment preparation

Follow the steps in Sect. 6.1.2 of this procedure except for reference; use Ref. 6 under Sect. 3 of this procedure.

Operational check

To do the operational check, follow the instructions under Sect. 20.2, Calibration of Gas Flo Proportional Alpha Counters.

Radiation measurement

1. Pull the Gas Flow Control to the FLUSH position.
2. Check the battery condition and replace if necessary.
3. After two minutes of flushing, set the Gas Flow Control to the OPERATE position.

   NOTE: The three steps above may be skipped if the field operational check was done immediately before the survey measurements are to be made.

4. Remove the face protector from the detector. Place the detector in contact with the surface to be measured.

   CAUTION: The probe face is very thin and can be easily punctured; avoid sharp objects.

5. Read the radiation intensity in cpm. The black pointer is used with the lower ranges up to 5K cpm. Above 5K cpm, the black pointer disappears and a red pointer appears. The red pointer is used with the two upper scales. Watch the pointer long enough to get an average reading.
6. When survey is complete, push the Gas Flow Control switch to OFF, turn the rate meter switch to OFF, and replace the detector face.
7. Return the equipment to proper storage.

Documentation

Enter the measured data in the Field Data Log Book on ORNL-RASA data forms (see Exhibit 13.2). The data entries will include site identification, date, instrument technologist initials, locations of surveyed areas, the radiation measurement results (cpm) for each area, and the instrument identification number.

Instrument limitations

For instrument limitations, refer to Sect. 5, Environmental, paragraph B, Specification; and Sect. 1, General, of the Technological Manual for the Gas Proportional Alpha Counter (Ref. 6).

13.3 BETA-GAMMA RADIATION MEASUREMENTS

13.3.1 Purpose

The purpose of this procedure is to describe the methods used to measure beta-gamma radiation on equipment, building, and ground surfaces.

13.3.2 Applicability

This procedure applies to beta-gamma radiation measurements made by ORNL-RASA personnel using portable radiation survey instruments.

13.3.3 References

1. Sect. 13.2, Alpha Radiation Measurements
2. Sect. 13.6, External Gamma Radiation Measurements
3. Sect. 20.5, Calibration of Geiger-Mueller Survey Meters
4. Sect. 20.10, Calibration of Portable Gamma-Scintillation Detectors
5. Eberline Instrument Company Technical Manual, Geiger Counter Model E-120/E-120G

13.3.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

13.3.5 Responsibilities

13.3.5.1 Site Leader

The site leader is responsible for implementation of this procedure.

13.3.5.2 Instrument Technologist

The instrument technologist is responsible for making and recording beta-gamma radiation measurements at the site, according to this procedure.

13.3.6 Procedure

13.3.6.1 Equipment

1. Eberline Geiger Counter Model E-120 (see Exhibit 13.4)
2. ORNL-type side window G-M tube assembly
3. Two D size dry cells of any type (1.5 V nominal); see Sect. 6.5 of this procedure for precautions
4. Field check source (depleted ^{238}U check source, same as specified in Sect. 20.10, Calibration of Portable Gamma-Scintillation Detectors)
5. Headphone set (optional)

13.3.6.2 Equipment Preparation

1. Remove the Geiger Counter from its storage in the mobile laboratory and check for physical damage. Report any damage to the site leader.
2. Install the batteries, if needed, following instructions in Sect. IV of the Technical Manual, Maintenance (Ref. 4).
3. Connect the probe cable to the BNC connector; connect the optional headphone if desired.

   NOTE: Steps 1 to 3 may be skipped as applicable.

4. Check the battery condition before each use by turning the selector switch to BATTery check position. The meter should be within the BATT OK area. If not, see Sect. 6.5 of this procedure.
5. Refer to Sect. 6.5.2 of Sect. 20.5, Calibration of Geiger-Mueller Survey Meters, for field check procedures.

13.3.6.3 Beta-Gamma Radiation Measurement

1. To measure the beta-gamma activity use the probe with the window open. Place the probe grill face in contact with the surface being measured.
2. Set the range selector switch to the scale that will provide meter deflection of at least ten percent of full scale. (The selector switch has X.1, X1, and X10 scales.)
3. To measure gamma activity only, repeat steps 1 and 2 above with the probe window closed.

13.3.6.4 Documentation

All beta-gamma and gamma measurements are entered in the Field Data Log Book on ORNL-RASA data forms (see Exhibit 13.2, Sect. 13.2, Alpha Radiation Measurements, for indoor data form and Exhibit 13.9, Sect. 13.6, External Gamma Radiation Measurements, for outdoor data form) for the site survey. The meter has scales both in mR/h and cpm. Record data only in cpm. Documentation includes identifications of areas surveyed, meter reading (cpm), time and date of survey, initials of instrument technologist, and the instrument identification number.

NOTE: Low energy gamma radiation can cause considerable error in the mR/h reading. Refer to Sect. II of the Technical Manual, Operation, paragraph C, Using the Instrument, item 3, Interpretation of Indications (Ref. 4).

13.3.6.5 Battery Installation and Replacement

For battery installation and replacement, refer to Sect. IV of the Technical Manual, Maintenance, paragraph A, Disassembly and Reassembly (Ref. 4).

CAUTION: See the Technical Manual, Sect. I, General, paragraph B, Specification (3) Power, and (4) Environmental, for battery life and temperature limitations for various battery types.

13.4 TRANSFERABLE ALPHA AND BETA-GAMMA MEASUREMENTS

13.4.1 Purpose

The purpose of this procedure is to provide guidelines for measuring transferable alpha and beta-gamma radioactivity on equipment and building surfaces.

13.4.2 Applicability

This procedure applies to measurement of transferable alpha and beta-gamma radioactivity on equipment and building surfaces at RASA survey sites.

13.4.3 References

1. Sect. 13.2, Alpha Radiation Measurements
2. Sect. 20.1, Calibration of Alpha Scintillators
3. Sect. 20.3, Calibration of Alpha Smear Counters
4. Sect. 20.8, Calibration of Beta-Gamma Smear Counters

13.4.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

13.4.5 Responsibilities

13.4.5.1 Site Leader

The site leader will be responsible for the implementation of this procedure.

13.4.5.2 Instrument Technologist

The instrument technologist will determine transferable alpha and beta-gamma radioactivity according to this procedure.

13.4.6 Procedure

13.4.6.1 Transferable Alpha Radioactivity Determination

Equipment and supplies

1. filter papers (Watman 50 or equivalent)
2. glassine envelopes
3. counting equipment
   a. ZnS phosphor and photomultiplier tube
   b. pre-amplifier (ORNL-type, unity gain)
   c. high voltage power supply (0.3 kV, Ortec Model 456 or equivalent)
   d. linear amplifier (Ortec Model 490B or equivalent)
   e. counter timer (Tennelec Model TC 562P or equivalent)
   f. sample holder
   g. alpha calibration source (refer to sources in Sect. 20.1, Calibration of Alpha Scintillators)
4. Alpha Smear Counter Log Book
5. Field Data Log Book

Smear sample collection

1. Assign identification numbers to the filter papers, if not already stamped on filters.
2. Take a smear sample from the center of a particular area to be surveyed. The smear is taken by wiping approximately 100 cm^2 of surface using moderate pressure applied by the tips of the first two fingers to the back of the filter paper. In general, a smear sample is taken over at least each 100 ft^2 of surface. More locations are sampled if preliminary surveys with portable instruments warrant detailed sampling. After wiping the particular surface, the filter paper is placed in a glassine envelope prior to counting in the mobile laboratory.
3. In the Field Data Log Book, enter the identification of the smear sample next to the area identification. (See field data form for indoor survey, Exhibit 13.6, Sect. 13.2, Alpha Radiation Measurements.)
4. Repeat steps 2 through 3 above until all the areas have been smeared.
5. After a minimum 4-h delay (to allow for decay of short-lived surface activity) proceed to count the smear samples in the mobile laboratory.

Alpha smear counting

1. Refer to the Alpha Smear Counter Log Book for instrument setup. (The instrumentation is normally set up and ready for operation.)
2. Set the instrument controls according to the values indicated in the log book.
3. Follow Sect. 20.3, Calibration of Alpha Smear Counters, for field calibration of the instrument.
4. After field calibration and determination of the background count rate (cpm), place the first smear sample in the sample holder. Count the sample for one minute.
5. Record the count data on the smear data form sheet (form UCN 1632 (Exhibit 13.6). The data should include the sample identification, date and time of counting, counting duration, gross and net count rate and initials of the instrument technologist. The reduced data (Sect. 6.3) is then recorded in the Field Data Log Book.
6. Repeat steps 4 and 5 for all smear samples.
7. Turn off the equipment after all smear samples have been counted.
8. Return all smear samples and completed smear data forms to ORNL for permanent archiving in the raw data file for the appropriate site.

13.4.6.2 Transferable Beta-Gamma Radioactivity Determination

Equipment and supplies

1. Filter papers (Watman 50 or equivalent)
2. Glassine envelopes
3. Counting equipment

   a. thin window G-M detector with sample holder housed in a lead shield
   b. absorbers for the slotted sample holder rack
   c. pre-amplifier (G-M tube type, Tennelec or equivalent)
   d. high voltage power supply (0-3 kV, Ortec 456 or equivalent)
   e. linear amplifier (Ortec Model 490B or equivalent)
   f. counter-timer (Tennelec Model TC 562P or equivalent)
   g. beta standard calibration source (Eberline Sr-90 or Tc-99 beta source, same as Sect. 20.8, Calibration of Beta-Gamma Smear Counters)
   h. Beta-Gamma Smear Counter Log Book
   i. Field Data Log Book

Smear sample collection

Follow steps 1 through 5 of Sect. 6.1.2 of this procedure.

Beta-gamma smear counting

1. Refer to the Beta-Gamma Smear Counter Log Book for instrument setup. (The instrumentation is normally set up and ready for operation.)
2. Set the controls according to the values indicated in the log book.
3. Follow Sect. 20.8, Calibration of Beta-Gamma Smear Counters, for field calibration and obtaining background count rate.
4. Place the smear sample on the sample holder and close the shield door.
5. Beta-gamma discrimination is obtained using an absorber between the sample and the detector. Use the absorber as necessary.
6. Count the sample for one minute and the gross count rate. Record on the smear data form (UCN 1632, see Exhibit 13.6) the smear sample identification, count data, gross and net count rate, counting duration, time and date of counting, and initials of the instrument technologist. The reduced data (Sect. 6.3) is then recorded in the Field Data Log Book.
7. Repeat steps 4 through 6 above until all samples have been counted.
8. Turn off equipment after all samples have been counted.
9. Return all smear samples and smear data sheets to ORNL for permanent archiving in raw data file for the appropriate site.

13.4.6.3 Data Reduction

1. To convert the net count rate data into the desired units (dpm/100 cm^2), the following formula must be used:

$$\text{activity (dpm/100 cm}^2 = \frac{A}{B},$$

where

A = net count rate (cpm), as determined in step 6.1.3-4 and 6.2.3-5,
B = calibration factor (cpm/dpm), as determined from Sect. 20.3, Calibration of Alpha Smear Counters, and Sect. 20.8, Calibration of Beta-Gamma Smear Counters (conversion factor is provided on tag on smear counter).

13.5 GAMMA EXPOSURE RATE MEASUREMENTS (PRESSURIZED ION CHAMBER)

13.5.1 Purpose

The purpose of this procedure is to provide guidelines for measuring external gamma radiation exposure rates in buildings and over ground surfaces using the pressurized ion chamber.

13.5.2 Applicability

This procedure applies to the measurement by ORNL-RASA personnel of external gamma radiation exposure rates at RASA sites.

13.5.3 References

Instruction Manual for Environmental Radiation Monitor, Model RSS-111, Reuter Stokes, Cleveland, Ohio

13.5.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

13.5.5 Responsibilities

13.5.5.1 Site Leader

The site leader is responsible for the implementation of this procedure.

13.5.5.2 Instrument Technologist

The instrument technologist is responsible for measuring external gamma radiation exposure rates according to this procedure.

13.5.6 Procedure

13.5.6.1 Equipment and Supplies

1. Pressurized Ionization Chamber (PIC) - Reuter Stokes Portable Environmental Radiation Monitor Model RSS-111

   This system includes the following:

   a. monitor
   b. strip-chart recorder
   c. digital display
   d. auto-disconnect battery pack with batteries
   e. tripod

2. Field Data Log Book
3. stop watch

13.5.6.2 Equipment Setup and Operation

NOTE: The following is a brief procedure for the operation of the PIC. The instrument technologist should refer to the Manufacturer's Instruction Manual for details not covered in this brief procedure.

1. With the sensor head housing, handle, and connectors facing upward, attach the tripod. (The tripod is equipped with a mounting stud modified from a stainless steel socket head cap screw that is held in place on the tripod.) Secure tripod to sensor head.
2. Extend the legs of the tripod to a position so that the center of the ion chamber housing is approximately 3 ft above the floor or ground surface.

3. Set the sensor head upright and connect cable.
4. Place the control and read-out housing 10 to 15 ft from the sensor head.
5. Ensure that the ELECTROMETER and MODE switches are both in the OFF position, then connect the cable to the readout housing.
6. If the system is to be operated on A.C. power, connect the line cord to the control housing.

   CAUTION: Do not operate the system on A.C. line voltage with the battery pack removed or permanent damage will result.

7. Determine the charge status of the 300 V dry cell battery (bias voltage supply to sensor) by the following procedure: turn on DISPLAY/RECORDER switch to BATT position and depress two switches; the one immediately below the digital display device, designated PUSH-TO-READ, and the one designated 300 V. The charge status of the 300 V battery will appear on the digital display in percent of charge remaining. Display will appear for approximately 30 s. There is essentially no drain on this battery, but it is subject to normal deterioration as indicated by the manufacturer's shelf-life specification. This battery should be replaced when the charge degrades to approximately 85%. Refer to paragraph 4.3 of the Instruction Manual for instruction.

   To determine charge status of the -14-, +14- and +12-V lead-acid type batteries, individual voltmeters, depress a switch immediately below the meters. If needle is in or near shaded area of meter, a recharge is recommended. See the appropriate section of the Instruction Manual.

   A 0-10 V recorder or external voltmeter may be connected to the BNC type signal output connector, if desired.

   Place the MODE switch in BATT or A.C. position. Place the ELECTROMETER switch in its ZERO position; wait approximately 60 s before proceeding, to allow transient charging currents to die out. Place the ELECTROMETER switch in it READ position; after a delay of approximately 10 s the signal will appear on the chart recorder. The auto-ranging recorder sensitivity is electronically switched over two ranges; 0-50 μR/h (low range) then switching to 250 μR/h (high range) and back to low range again.

   NOTE: The recorder is normally not used for ORNL-RASA measurements.

   To have signal appear on the display, turn on the DISPLAY/RECORDER switch and depress the PUSH-TO-READ switch. The signal will appear for approximately 30 s.

   NOTE: Although the display is not illuminated after the $\simeq$ 30 s, the unit is still operating causing a drain on the battery. For economical power usage while in BATT mode, turn the DISPLAY/RECORDER switch off when a displayed signal is no longer necessary.

When measurement is finished, turn ELECTROMETER and MODE switches off. Dismantle the instrument and return to storage.

8. Reset the accumulator to zero and start the stop watch. After a predetermined length of time (typically 30-60 min), record the accumulator reading and the elapsed time.

   NOTE: Observe the accumulator and allow it to advance to the next digit before ending the counting period.

9. Convert the elapsed time into hours and calculate the exposure rate:

$$\mu R/h = \frac{\text{accumulated reading (muR)}}{\text{time interval (h)}} .$$

13.5.6.3 Data Documentation

Enter the external gamma radiation measurements in the Field Data Log Book. The entries should include site identification (coded if necessary), the locations of the measured areas, and the radiation levels.

13.6 EXTERNAL GAMMA RADIATION MEASUREMENTS

13.6.1 Purpose

The purpose of this procedure is to provide guidelines for external gamma radiation measurements made at ORNL-RASA survey sites.

13.6.2 Applicability

This procedure applies to the external gamma radiation measurements of an ORNL-RASA survey site using a portable gamma scintillator.

13.6.3 References

1. Sect. 11.2, Specification of Measurement Grid System and Maps
2. Sect. 20.10, Calibration of Portable Gamma Scintillation Detectors
3. Victoreen, Inc., Instruction Manual for Model 490, THYAC III, Victoreen Pat No. 490-1A, Victoreen, Inc.
4. ANSI N323-1978, American National Standard, Radiation Protection Instrumentation Test and Calibration, the Institute of Electrical and Electronic Engineers, Inc., 345 East 47th Street, New York, New York 10017, 1978 (for guidance only).

13.6.4 Definitions and Abbreviations

13.6.4.1 Definitions

GRID. A network of parallel horizontal and vertical lines forming squares on a map which may be overlaid on a property parcel for the purpose of identification of exact locations.

GRID BLOCK. A square defined by two adjacent vertical and two adjacent horizontal grid lines.

GRID POINT. Intersection of horizontal and vertical grid lines and/or the intersection of a grid line and the perimeter of a structure.

Also see Sect. 1.5 of this manual, Terminology.

13.6.4.2 Abbreviations

NEDA. National Electronics Distributors Association

Also see Sect. 1.5 of this manual, Terminology

13.6.5 Responsibility

13.6.5.1 Site Leader

The site leader is responsible for the implementation of this procedure.

13.6.5.2 Instrument Technologist

The instrument technologist is responsible for performing the gamma scan of a gridded survey site according to this procedure.

13.6.6 Procedure

This procedure is a brief description of the operation of the gamma scintillation detector. For more detailed information about the instrument, refer to the manufacturer's Instruction Manual (Ref. 3).

13.6.6.1 Equipment and Supplies

1. Victoreen Portable Ratemeter, Model 490, THYAC III, 0-800, 0-8,000, 0-80,000, 0-800,000 counts per minute, Victoreen Instrument Company (see Exhibit 13.8)
2. Battery - two size D flashlight cells, NEDA Type 13
3. Gamma scintillation probe, Model 489-50, [1.25-in. by 1.50-in. sodium iodide (thallium activated) scintillation crystal], Victoreen Instrument Company
4. ORNL-RASA Portable Instrument Log Book for the Model 490 THYAC III instrument
5. Headphone set to match instrument
6. A 6-ft cord attached to the top of the scintillation probe for use in handling the probe while scanning

13.6.6.2 Equipment Set Up

1. Remove the ratemeter and attach probe from its storage in the mobile laboratory and check for physical damage. If physically damaged, do not use, and report damage to the site leader.
2. Hand tighten the cable connection.
3. Check the battery condition by turning the function switch to bat position. If battery is bad, replace per Sect. 6.5 of this procedure.
4. Attach the headphone set to the phone connector of the instrument. The headphone is used to provide an audio indication of gamma radiation intensity.
5. The Victoreen Instrument Manual for Model 490, THYAC III, stipulates that periodic performance tests of the instrument be made according to paragraphs 4.5 and 5.4, and that records be kept in general conformance with guidelines in paragraph 4.5 of ANSI N323-1978.

For performance tests, refer to Sect. 20.10, Calibration of Portable Gamma Scintillation Detectors.

13.6.6.3 Range and Response Settings

Range setting

Initially set the range at the highest level (x 1000). If the meter reading is less than ten percent of full scale, switch to the range of the next lower level (x 100). Repeat this procedure until the reading is over 10% of full scale.

Response setting

The Model 490 Ratemeter has three response times designated slow, med, or fast, which correspond to approximately 15 s, 5 s, and 1.5 s, respectively. Generally, the slow response is used with the two most sensitive ranges for very accurate reading; the med response is used for the majority of the readings; and the fast response is used with the x 1000 range. Set the response switch to med.

13.6.6.4 Instrument Operation

Discrete measurements

1. Turn on the checked and calibrated instrument.
2. Place the scintillator against the surface to be surveyed or at the specified distance from the surface (i.e., 3 ft height).
3. Observe the count rate as displayed on the rate meter. Note the average value in cpm and record in the Field Data Log Book on the ORNL-RASA outdoor data form (Exhibit 13.9).
4. When survey is complete, turn the instrument off.

Grid block scanning

1. Turn on the checked and calibrated instrument and put on headphones.
2. Scan the grid by swinging the scintillation detector from left to right while moving forward. The width of the swing should be three to four feet. The detector should be as low as practical without hitting rocks or hard objects.
3. Use the audio response of the detector to locate areas of anomalous radiation levels. Periodically observe the meter response to obtain an estimate of the average levels measured.
4. Sweep through the grid from one end to the other as many times as necessary until the entire grid is scanned. Note the locations and associated surface and 3-ft height response at all locations with elevated activity.
5. Enter the average observed detector response (cpm) in the Field Data Log Book on the ORNL-RASA outdoor data form (Exhibit 13.9) for the appropriate grid block location. Also record all meter readings from locations of elevated gamma activity.
6. Repeat steps 2 through 5 above for each succeeding grid block until all grid blocks have been scanned.
7. When all the assigned grid blocks have been scanned, turn the instrument off.

13.6.6.5 Battery Replacement

Should the bat check in Sect. 6.2, step 3, of this procedure indicate the battery needs replacement, follow step 3.1, page 8 of the Instruction Manual (Ref. 3).

13.7 GAMMA LOGGING OF AUGERED HOLES

13.7.1 Purpose

The purpose of this procedure is to provide guidelines for gamma logging of augered holes.

13.7.2 Applicability

This procedure applies to the gamma logging of augered holes at RASA sites being surveyed by ORNL-RASA personnel.

13.7.3 References

1. Sect. 14.1, Soil and Sediment Sample Collection
2. Sect. 14.2, Water Sample Collection
3. Sect. 17.1, Inspection of Equipment and Personnel for Contamination
4. Sect. 20.14, Calibration of Gamma Hole-Logging Equipment
5. Eberline Instrument Corporation, Technical Manual, Mini Scaler Model MS-2, Santa Fe, New Mexico, 1971

13.7.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

13.7.5 Responsibilities

13.7.5.1 Site Leader

The site leader is responsible for the implementation of this procedure at site surveys. He also determines the locations for auger holes.

13.7.5.2 Instrument Technologist

The instrument technologist performs the gamma logging of auger holes according to this procedure.

13.7.6 Procedure

13.7.6.1 Equipment and Apparatus

1. Mini scaler - Model MS-2, Eberline Instrument Corporation
2. Shielded scintillation detector, Victoreen Model 489-55 probe inside 1/2-inch thick lead shield with 1/4-inch slots located at midpoint of the crystal. The detector should be placed in a plastic bag for protection from the drilling environment.
3. Unshielded scintillation detector (Victoreen Model 489-55 probe); the detector should be placed in a plastic bag for protection from drilling environment.
4. Winch assembly mounted on a tripod
5. Sufficient length of Sch. 40 plastic pipe (having one end capped) to case hole depth with rope tied around the uncapped end for use in handling pipe.
6. Battery pack - Globe Gel/Cell Rechargeable Pack, PP 1200-12V, 7.5 A.H. capacity
7. Eberline Model MS-2 mini scaler and timer
8. Signal cable of sufficient length to reach depth of auger holes (marked every 6 inches).
9. Battery cable

See Exhibits 13.10 and 13.11 for logging equipment and instrumentation.

13.7.6.2 Equipment Preparation

Mini Scaler

Equipment set up

1. Check the equipment and apparatus for physical damage and report any damage to the site leader.
2. Transport the equipment and supplies to the site where holes are to be augered.
3. Connect battery to the mini-scaler through the BATTERY connector (pin 1 negative, pin 2 positive).
4. Set controls as follows:
   a. H. V. ADJUST - Adjust H.V. to provide a 900-V output at the detector end of cable (pot setting is dependent on cable length).
   b. THRESHOLD - 5.00
   c. WINDOW IN-OUT-OUT
   d. TIMED-STOP-MAN--TIMED
5. Turn POWER switch ON. Push START-RESET switch.

Operation check.

1. Set TIMED-STOP-MAN switch to TIMED.
2. Set COUNT TIME-IN MINUTES switches to 1 and X.1. Press START-RESET switch. Unit should stop counting after six seconds, registering approximately 360 counts.
3. Under conditions 1 and 2, meter should read 3,600 counts per minute. If not, check battery. If equipment needs calibration, see Sect. 20.14, Calibration of Gamma Hole-Logging Equipment.
4. Turn TEST switch OFF.
5. Connect the scintillation detector to the Mini Scaler with the signal cable.
6. Set THRESHOLD to 5.00 and WINDOW IN-OUT switch to OUT.
7. Set the H.V. at a value indicated on the Instrument Log Book.

13.7.6.3 Subcontractor Equipment Check

Before allowing the subcontractor to auger holes on the site, check his equipment with the alpha, beta-gamma and gamma scintillation detectors to make sure that his equipment is not contaminated (see Sect. 17.1, Inspection of Equipment and Personnel for Contamination).

13.7.6.4 Hole Depth Determination

In normal situations, the drilling subcontractor augers a hole to the depth of an undisturbed layer of natural soil or when bedrock is encountered. In some instances during the augering process (while the auger is still in the hole), the unshielded gamma scintillator is used to monitor the radiation

levels at different depths of the hole. This is done to determine at what depth augering can stop and to provide data in holes that could close after the auger is removed due to wet conditions. At the discretion of the instrument technologist, the augering process is interrupted and the auger head is disconnected from the auger. The unshielded probe is then lowered through the hollow stem of the auger and data obtained (see Sect. 6.5). At this stage, the tripod is not normally used. When the radiation levels remain constant (at background levels), augering may be terminated. The auger is removed from the hole and comprehensive hole logging is conducted.

13.7.6.5 Hole Logging

1. Set the plastic pipe down to the bottom of the hole by lowering it into the hole with the rope. If significant water is present in the hole, the pipe may have to be secured to hold it down.
2. Set the winch assembly above the augered hole. Attach the shielded detector to the cable (steel and signal) on the winch assembly.
3. Lower the detector to the lowest point in the hole and record the depth. Fill out the data sheet as required (Exhibit 13.12).
4. Set TIMED-STOP-MAN switch to TIMED.
5. Set COUNT TIME-IN MINUTES switches to 1 and X1. Press START-RESET switch. Counting should automatically stop after one minute.
6. Record the cpm against depth.
7. Raise the detector 6 or 12 in. and press START-RESET switch.
8. Repeat steps 5 through 7 until the detector has been raised to ground level.
9. Repeat steps 1 through 8 for all other augered holes on the same site.
10. After gamma logging is completed, turn the MS-2 mini scaler off and disconnect the instrumentation for return to the mobile laboratory.

Special notes and instructions

1. Note the repeatable lowest readings for each hole. They will be considered the background radiation level. If the reading falls significantly below the background levels, it may indicate instrument malfunction, particularly with low battery charge.
2. Note also the depth at which the maximum readings occur. This is the depth at which one of the soil samples should be taken (see Sect. 14.1, Soil and Sediment Sample Collection).
3. If water is present in any of the holes, a sample may be taken for subsequent radionuclide analysis (see Sect. 14.2, Water Sample Collection).

13.7.6.6 Data Documentation

The information indicated in Exhibit 13.12 may be directly entered in the Field Data Log Book and used as a permanent data record.

13.8 ONSITE GAMMA SPECTROMETRY

13.8.1 Purpose

The purpose of this procedure is to provide a method for the operation of onsite field gamma spectrometers.

13.8.2 Applicability

This procedure applies to the two onsite gamma spectrometry systems utilized by ORNL-RASA and commonly referred to as the Adam and Eve systems. These systems are normally maintained on one of the mobile laboratories.

13.8.3 References

1. Sect. 13.11, Radon Flux Measurements
2. Sect. 15.8, Soil and Sediment Sample Preparation
3. Sect. 20.6, Calibration of On-Site Gamma Spectrometers
4. Sect. 20.17, Calibration of Charcoal Canisters
5. Nuclear Data ND-100 Pulse Height Analyzer Technical Manual
6. Tracor Northern TN 1314 Display Unit Technical Manual
7. Tracor Northern TN 1706 Pulse Height Analyzer Technical Manual
8. ORTEC 490B Linear Amplifier Technical Manual
9. ORTEC 456 High Voltage Power Supply Technical Manual
10. Tennelec Tennebin 3 Nimbin Power Supply Technical Manual

13.8.4 Definitions and Abbreviations

13.8.4.1 Definitions

See Sect. 1.5 of this manual, Terminology.

13.8.4.2 Abbreviations

cpm counts per minute

pCi picocurie

g gram

Also see Sect. 1.5 of this manual, Terminology.

13.8.5 Responsibilities

The ORNL-RASA manager has overall responsibility for this procedure, and the instrument technologist is responsible for the implementation of this procedure.

13.8.6 Procedure

13.8.6.1 Equipment, Apparatus, and Supplies

1. Adam or Eve onsite gamma spectrometer system - detailed listing of components of each system is provided in Exhibit 13.13, Component List for Onsite Gamma Spectrometry System
2. Adam or Eve log book
3. plastic sample bottles (approximately 3-in. diameter, 4-in. height).
4. reagent grade sodium chloride or Dunnite

13.8.6.2 Equipment Setup

The detectors, pulse height analyzer components, and support systems are all interconnected and ready for operation. If, for any reason, component disconnect or reconnect is necessary, contact the instrument technologist at ORNL-RASA and obtain the necessary information to reconnect the system.

13.8.6.3 General Procedure

1. Start Onan 4.5 Kw alternator system on the mobile laboratory.
2. Allow 15 min for system to warm up and stabilize.
3. Start Adam or Eve onsite gamma spectrometer by switching on in the following order:

   a. Nimbin Power Supply
   b. Display Module
   c. Pulse Height Analyzer
   d. Linear Amplifier
   e. High Voltage Power Supply (set to 800 volts)

4. Allow 15 min for system to warm up and stabilize.
5. Calibrate system following detailed instructions in Sect. 20.6, Calibration of Onsite Gamma Spectrometers. (See Sect. 6.5 of this procedure.)
6. Install blank (reagent grade sodium chloride or Dunnite) in detector system. To assure congruent sample geometry, depth of the standard, blank, and all samples to be counted must be equal.
7. Accumulate counts in the two regions of interest (channels 287-519 and 709-948) for a period of 10 min. For the Eve system, set counter for 10 min and press CLEAR and ACQUIRE switches on the pulse height analyzer. For the Adam system, consult the ND-100 Pulse Height Analyzer Technical Manual for detailed discussion and instructions on data acquisition procedure.

8. Record background counts for the two regions of interest. For the Eve system, place REGION switch in the CLEAR position. Rotate cursor knob until channel 287 appears on the CRT screen. Place REGION switch in the ENTER position. Rotate cursor knob until channel 519 appears on the CRT screen. Place REGION switch in the ENTER position and read the accumulated counts for the 287-519 region on the CRT. Place REGION switch in the CLEAR position. Repeat this operation using 709 for the initial and 948 for the final values. For the Adam system, consult the ND-100 Pulse Height Analyzer Technical Manual for detailed discussion and instructions on data recovery procedure.
9. Remove blank sample and install the soil sample prepared according to Sect. 15.8, Soil and Sediment Sample Preparation.
10. Count for 10 min and record accumulated counts by following steps 2 and 3 of this section.
11. Remove sample from detector and perform calculations according to Sect. 6.4 of this procedure. (See Sect. 6.5 of this procedure.)
12. Enter into the Adam or Eve log book the sample number, date, technologist's name, blank background sample counts, soil sample counts, conversion factor, and final sample value (pCi/g of radium).

13.8.6.4 Calculations

1. Net Counts Per Minute - determine net counts per minute from blank sample using the following equation:

$$\frac{(B-a + (C-b)}{T} = A,$$

where

B = gross sample counts (287-519 window),
a = background counts (287-519 window),
C = gross sample counts (709-948 window),
b = background counts (709-948 window),
T = counting time in minutes (normally 10),
A = net counts per minute (cpm).

2. Radium Concentration

Determine radium concentration using the equation

$$A \times Z = R,$$

where

A = net counts per minute (cpm from equation #1 above),
Z = calibration factor (pCi/g/cpm) from line 2, Sect. 6.6 of Sect. 20.6, Calibration of Onsite Gamma Spectrometry,
R = estimated ^{226}Ra concentration in pCi/g.

13.8.6.5 Special Notes and Instructions

1. If the spectra resulting from the analysis differ significantly from the normal distribution, check system gain. If spectra still do not conform to radium spectra, call the instrument technologist at ORNL-RASA and send the sample to the laboratory with instructions to test for other contaminants.
2. Rerun the background each time the mobile laboratory is relocated.
3. Use of the systems for charcoal canister counting is detailed in Sects. 13.11, Radon Flux Measurements, and 20.17, Calibration of Charcoal Canisters.

13.9 RADON MEASUREMENTS

13.9.1 Purpose

The purpose of this procedure is to provide the guidelines for radon measurements using Wrenn Chambers, Lucas Cells, or ORNL Cells.

13.9.2 Applicability

This procedure applies to the continuous measurement of radon using Wrenn Chambers and to the grab sample radon measurements using Lucas or ORNL Cells.

13.9.3 References

1. Sect. 13.12, Meteorological Data Collection
2. Sect. 20.4, Calibration of Alpha Spectrometry Systems
3. Sect. 20.15, Calibration of Wrenn Chambers
4. Sect. 20.16, Calibration of Lucas and ORNL Cells

13.9.4 Definitions and Abbreviations

13.9.4.1 Definitions

See Sect. 1.5 of this manual, Terminology.

13.9.4.2 Abbreviations

DOS Disk Operating System

NIM Nuclear Instrumentation Module

SCA Single Channel Analyzer

Also see Sect. 1.5 of this manual, Terminology.

13.9.5 Responsibilities

13.9.5.1 Site Leader

The site leader is responsible for the implementation of this procedure.

13.9.5.2 Instrument Technologist

The instrument technologist uses this procedure for radon measurements using either the Wrenn Chamber, Lucas Cell, or ORNL Cell.

13.9.6 Procedure

This procedure will be subdivided into two subprocedures: one for continuous radon measurement using the Wrenn Chamber and the other for grab sample radon measurement using the Lucas or ORNL Cell.

13.9.6.1 Procedure for Continuous Radon Measurements

Instrumentation and setup

Instrumentation.

1. 2 Wrenn Chambers (see Exhibit 13.16),
2. 1 Nuclear Counting System consisting of the following:
   a. one high voltage power supply - ORTEC 456, 0-3 kV
   b. two Amplifier and single channel analyzer-AMP & SCA, ORTEC 490B
   c. one NIM Bin power supply - Tennelec Tennebin 3
   d. +5 volt power supply and display
3. One data reduction system consisting of the following:
   a. pocket terminal
   b. line printer - ORTEC 777A with sufficient paper tape
   c. computer - NDT-COMP 8, microcomputer and controller
4. Tapes (adhesive),
5. Radon Data Log Book,
6. Electrical outlet box (four outlets).

Transport the above instrumentation and accessories to the location where continuous radon measurements will be performed.

NOTE: The nuclear counting system and the data reduction system are mounted in one cabinet.

Instrumentation setup.

1. Set the Wrenn Chambers at a location where measurements are to be made. Connect the signal, high voltage, and preamplifier cables to their respective connectors on the Wrenn Chambers. (Note: Each type of cable has a different connector; therefore, there is no chance for misconnecting the cables.)
2. Connect the other ends of the signal, high voltage, and preamplifier cables to the nuclear instrumentation. The high voltage and preamplifier cables can be connected at any location on the high voltage power supply and the preamplifiers, respectively. The signal cables, however, should be connected to their respective input connectors. The signal cables are numbered to correspond to the Wrenn Chamber number and nuclear instruments.
3. Determine from the Wrenn Chamber Log Book the proper settings for the following for each of the nuclear counting systems, and set them accordingly (see Sect. 20.15, Calibration of Wrenn Chambers).

   a. coarse gain
   b. fine gain
   c. window (upper)
   d. window (lower)

4. With all the power switches in off position, connect the instrumentation cables to an outside power supply. (It may be necessary to tape down the power supply cable.)

Sample collection and data reduction

1. Turn the electronics on in the following order:

   a. NIM bin power,
   b. high voltage power (set at 0 before turning on, and then slowly raise to 1,000 volts), and
   c. line printer power (make sure line printer is set on auto recycle); press reset button.

2. Connect the pocket terminal and enter information asked for by computer. The information requested and specifications are indicated below (use leading zeros as required):

   a. month - 3 letters
   b. day - 2 digits
   c. year - 4 digits
   d. hour - 2 digits (use 24-hour clock, i.e., 4 p.m. = 16)
   e. minute - 2 digits
   f. Wrenn Chamber number - 2 digits
   g. printout interval in seconds - as desired (normally 3600 seconds)

h. conversion factor (pCi/cpm) - see Radon Data Log Book (the conversion factor is based on the hygrometer reading and can be found in the Wrenn Chamber Log Book); refer to Procedure 13.12, Meteorological Data Collection, for relative humidity measurements.
i. background for the interval (in counts per interval)

After programming, the timer will begin at the entered time. Counts will begin accumulating for each channel. At the end of this counting interval, the instrumentation will automatically print out the date (at the beginning of tape) and chamber number, counts, and pCi/l of radon for the time interval chosen. Data collection and printout will continue until manually stopped. Attach the printouts to the data sheet.

3. The pocket terminal may be disconnected after programming.
4. When measurements are completed, turn electronics off, unplug the power source, and disconnect the power signal cables.

Documentation

Document on the Field Data Log Book the results of radon measurements from Wrenn Chambers.

13.9.6.2 Procedure for grab sample radon measurement using Lucas or ORNL cells

Instrumentation and setup

Instrumentation.

1. Lucas or ORNL Cells (see Exhibits 13.9-2 and 13.9-3)
2. vacuum pump system
3. nuclear instrumentation consisting of the following (or their equivalent):

a. Lucas Cell

- Tennelec Tennebin 3 power supply
- Ortec Model 420 single channel analyzer
- Tennelec Model TC 545A counter timer
- Tennelec Model TC 211 linear amplifier
- ORNL high voltage power supply
- ORNL preamplifier

b. ORNL Cell

- Tennelec Tennebin 3 power supply
- Ortec Model 490B amplifier and single channel analyzer
- Tennelec Model TC 545A counter timer
- Tennelec Model TC 948 high voltage supply
- ORNL preamplifier

NOTE: The instrumentation above is on mobile laboratory E5954. Equivalent equipment is on other mobile laboratories.

c. Data Reduction System consisting of the following:

- Commodore CBM Model 4032 or PET Computer
- floppy disk drive or cassette tape player
- printer

d. Radon Data Log Book
e. Alpha Spectrometer Log Book
f. Radon Cell Log Book

Instrumentation setup. Refer to Radon Cell Log Book for the instrumentation setup for counting the Lucas or ORNL Cells. Set the different instrument parameters as indicated in the log book.

Cell evacuation. Either cell can be evacuated using the following procedure:

1. connect either cell to the vacuum header;
2. open Lucas Cell by aligning the stop cock with the axis of the stem (make sure stop cock is properly greased);
3. open ORNL Cell by pushing the valve stem to the mark on the stem;
4. check to make sure the vacuum pump and vacuum gauge are both connected to the power supply;
5. turn on the vacuum pump and watch the gauge; for Lucas Cell, evacuate to 50 μm; for ORNL Cell, evacuate to 100-150 μm; and
6. when evacuated to the desired vacuum, close off the valve and remove from the vacuum header; turn off vacuum pump.

Background count. Count the ORNL Cell or Lucas Cell for background and note the background value on the applicable log book. (Note: see the counting procedure in Subsection 6.2.1.6 of this procedure.)

Sample collection. Attach blank label to cell. Take the ORNL Cell or Lucas Cell to the location where radon sample is to be taken. Release the vacuum by opening the valve. Record the location and time the sample is taken on the label. Close the valves after sample collection. Store the cell a minimum of four hours before counting.

Enter the following information on the Radon Cell Log Book as applicable:

Cell No. _____

Conversion factor _____

Background _____

Time sample taken _____

Location of sample _____

Sample counting.

1. Place the samples into their respective detector wells and wait for 30 s to 1 min before counting to allow the system to stabilize.
2. Note the time counting was started and count for 10 min.
3. Note the number of counts.
4. Calculate the time (minutes) from the time sample was taken to the midpoint of the counting time.

Data reduction. The following data reduction procedures are for the cassette and floppy disk versions. The formula used in the calculation of radon concentration is

$$pCi/l = cpm \times C \times e^{\lambda t} \times \frac{1}{v} ,$$

where

cpm = net count rate,
C = conversion factor, pCi/cpm,
λ = decay constant (7.55×10^{-3} h^{-1}),
t = time from sampling to midpoint of counting interval (in hours),
v = volume of cell (0.095 l - Lucas Cell)
(0.5 l - ORNL Cell).

Floppy disk

1. Turn on PET or Commodore computer (switch is located at rear left side).
2. Turn on Floppy Disk Drive (switch - left-hand back).
3. Place floppy disk in either drive (for example, Drive 0).

WARNING: DO NOT TURN OFF Floppy Disk Drive with disks in place. (This may erase the contents.) Follow step 3 and steps 5 through 7 under Cassette tape.

Cell care. After counting, the ORNL or Lucas Cells should be flushed by evacuating and releasing the vacuum several times for each cell. The cells should not be stored under evacuated conditions.

Documentation

For documentation of the Lucas or ORNL Cell analysis, use the Field Data Log Book.

13.9.6.3 Instrument Calibration

Periodically, the instrumentation will require calibration. Refer to Sect. 20.4, Calibration of Alpha Spectrometry Systems, for details. See Sect. 20.15, Calibration of Wrenn Chambers, and Sect. 20.16, Calibration of Lucas and ORNL Cells, for details of the calibration of Wrenn, Lucas, and ORNL Chambers.

13.10 MEASUREMENT OF RADON DAUGHTER ACTIVITIES IN AIR SAMPLES

13.10.1 Purpose

The purpose of this procedure is to provide guidelines for the collection of air samples and for the analysis of the samples for ^{222}Ra daughter activities.

13.10.2 Applicability

This procedure applies to the field collection and analysis of air samples for ^{222}Ra daughter activities.

13.10.3 References

None.

13.10.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

13.10.5 Responsibilities

13.10.5.1 Site Leader

The site leader is responsible for the implementation of this procedure.

13.10.5.2 Instrument Technologist

The instrument technologist collects and analyzes air particulate samples for ^{222}Ra daughters according to this procedure.

13.10.6 Procedures

13.10.6.1 Equipment, Apparatus, and Supplies

1. low volume air sampler (see Exhibit 13.10-1)
2. air filters - 0.45 μm
3. nuclear counting system (see Exhibits 13.10-2 and 10.10-3)
   a. display unit - Tracor Northern TN-1314
   b. pulse height analyzer - Tracor Northern TN-1706
   c. linear amplifier - Tennelec TC222
   d. high voltage power supply - Ortec 456 (0-35 kV)
   e. bin power supply - Tennelec Tennebin 3
   f. surface barrier detector
   g. filter sample holder
   h. forceps for insertion and removal of sample holder from detector

4. helium gas supply assembly
   a. gas tank
   b. gas pressure controller
   c. gas flow controller-indicator
5. stop watch
6. data reduction equipment
   a. Commodore CBM Model 4032 computer
   b. Commodore CBM Model 8050 dual drive, floppy disk
   c. Commodore Tractor Printer Model 4022
7. Radon Data Log Book
8. Alpha Spectrometer Log Book

13.10.6.2 Nuclear Counting System Set Up

NOTE: The nuclear counting system must be properly set up and ready for counting before collecting air samples.

1. The nuclear counting system is normally already set up in the mobile laboratories. The instrument technologist needs only to verify the correct interconnection.
2. Set or confirm the following settings for the instruments. (In order to assure that the settings indicated in this procedure are current, check the Alpha Spectrometer Log Book and confirm the indicated settings.)

High voltage power supply:		67 Volts
Linear amplifier: Coarse Gain		50 x 7.2
		(varies)
Pulse height analyzer:	ULD	10.0
	LLD	0.2
	Mode	PHA
	Horizontal	1/2
	Preset	Clock
	Conversion Gain	512
	Offset	0
	Time Bases	2 and B

3. Turn power on: bin power, high voltage power, linear amplifier power. Hold the data CLEAR button while power supplies are being turned on. This step may be skipped if the system is already in use.
4. Check out the system using the ^{228}Th check source. The 8.78 MeV alpha should be in channel 445. Adjust the fine gain and coarse gain as necessary.
5. Clear data after checking the system. Set a filter sample holder nearby. Proceed to collect air samples.

SUBJECT: FIELD MEASUREMENTS

13.10.6.3 Air Sample Collection and Counting

1. Check the air sampler for the following:

   a. power cables (gray) for the air pump motor and flow rate indicator are plugged into the electrical outlets mounted on the frame;
   b. air pump motor switch is OFF; (This will prevent inadvertent start of sampler when power is plugged in.)
   c. flow meter is connected to the flow rate indicator with a signal cable. Turn flow meter indicator switch to ON.

2. Using forceps, load a 0.45 μm air filter into the filter holder. Make certain the upper side of the filter faces the incoming air. Connect the filter holder to the sampler only when ready to take samples.
3. Take the air sampler, air filter holder, a stop watch, and the Radon Data Log Book to the sampling site.
4. Plug the long black cable to a power source. Note on the Radon Data Log Book the location and the time the sample is to be taken.
5. Turn the air pump motor switch on and start the stopwatch simultaneously. Collect the sample for 10 min. Note the air flow rate after 2 min of sampling and thereafter. The rate should be in the 10 to 15 Lpm (liters per minute) range.
6. After the 10-min sampling, turn off the air sampler. At the same time, stop the stopwatch, clear, and immediately restart it. Immediately move the air sampling equipment to the mobile laboratory, remove the air filter from the air sampler using forceps and load it into the sample counter. (No more than 2 min should elapse from the time sampling stops to the time counting starts.)
7. Start counting the sample (stopwatch should be at 2 min) and count for 10 min.
8. Stop counting (12 min elapsed time on stopwatch) and obtain the integral counts for the following regions, and record the counts for each region.

   a. Region 1 - Channels 280-308
   b. Region 2 - Channels 308-338
   c. Region 3 - Channels 338-400
   d. Region 4 - Channels 400-480

   Push the REGION level down to erase region data and set the region of interest.

   A region of interest is set by turning the CURSOR knob to the lower channel number first and pushing REGION level up to ENTER, and then turning the CURSOR knob clockwise to the higher channel number for the same region and entering again. As the CURSOR is moved, the channel number is indicated on the display unit. After the higher channel number of each region is entered, the integral count for that region is shown on the right-hand-most part of the display. ERASE the cursor setting for the region before obtaining the counts for the next region.
9. Allow a 3-min lapse between the first and the second counts.
10. Start (15 min on stopwatch) the 15 min count. After counting, obtain the integral counts for the regions in Step 8 above. Record the counts in the Radon Data Log Book (at the end of counting, the stop watch should show 30 min).

SUBJECT: FIELD MEASUREMENTS

Data reduction

1. Turn on the computer system.
2. Obtain and load the Minidisk 8050 into the CBM computer.
3. To interact with the computer, follow the instructions below.

Technologist action	CRT display	Function or comment
a. Type Load "*", 8 and push RETURN key		
b. Type RUN and push RETURN key		
c. Type /RNCONP and push RETURN key		
d. Type RUN and push RETURN key		
e. Enter air sampling rate in liters per minute and push RETURN key		
f. Enter uncertainty in percent (this is generally 5 percent)		
g. Enter Geometry Factor of the detector (see Instrument Log Book for this value)		
h. Enter uncertainty in percent (generally 3 percent)		
i. Enter the integral counts for the following regions for the 10-min count as they are called for by the computer Channels 280-308 Channels 308-338 Channels 400-480		
j. Repeat step (i) above for the 15-min count		
k. Enter location of sampling		
l. Enter date and time of sampling		

4. The computer will provide the radon daughter concentration and the printer will provide a printout. The printout serves as the record for the data reduction and may be filed as part of the record.
5. After data reduction, remove Minidisk from floppy disk drive. CAUTION: turn off floppy disk drive power first before turning off computer power. (This last step will prevent wiping out the disk on one of the systems.)

13.11 RADON FLUX MEASUREMENTS

13.11.1 Purpose

The purpose of this procedure is to provide guidelines for the determination of radon emanation from ground or floor surfaces.

13.11.2 Applicability

This procedure applies to the determination of radon flux at RASA survey sites by ORNL-RASA personnel.

13.11.3 References

1. Sect. 13.8, Onsite Gamma Spectrometry
2. Sect. 20.13, Calibration of Laboratory Gamma Spectrometry Systems
3. Sect. 20.17, Calibration of Charcoal Canisters

13.11.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

13.11.5 Responsibilities

13.11.5.1 Site Leader

The site leader is responsible for the implementation of this procedure.

13.11.5.2 Instrument Technologist

The instrument technologist determines radon flux according to this procedure.

13.11.6 Procedure

NOTE: Radon emanation from a surface gives an indication of the ^{226}Ra concentration underneath the area being surveyed. The emanation rate is affected by several factors which include soil porosity, moisture content, ambient temperature, and pressure. The use of charcoal canisters for measuring radon emanation provides only an indication of the relative magnitude of the radon source.

13.11.6.1 Sample Collection

Apparatus and supplies

1. Charcoal canisters (quantity as required), modified U.S. Army M11 gas canister with activated charcoal, cross-section 87 cm^2
2. Duct tape or caulk rope
3. Field Data Log Book

SUBJECT: FIELD MEASUREMENTS

Sampling locations

Radon emanation measurements may be made indoors or outdoors. The canisters may be placed randomly, over drains or cracked floors. If placed over drains, the drains must be covered entirely except the area under the canister.

The instrument technologist should confer with the site leader to determine the sampling locations. Once the sites are determined, mark them for canister emplacement.

Charcoal canister placement

NOTE: See Sect. 6.1.4 of this procedure for documentation requirements before proceeding with canister placement.

1. Remove one charcoal canister from its plastic bag.
2. Ground and concrete surfaces
   a. On ground surfaces, twist the canister about one cm into the ground. Seal the perimeter of the canister with some soil.
   b. Over concrete or floor surfaces, first wipe off any dirt. Place the canister over the surface and seal with duct tape or caulk rope around the canister.
3. Emplace the rest of the charcoal canisters following the above procedure.
4. Allow the canisters to remain for one to three days before retrieval.
5. When the canisters are retrieved, wipe them clean, if dirty, and place each canister into a plastic bag.
6. Let the canisters sit for at least 4 h before counting.

Sample documentation

1. Enter the identification of all the charcoal canisters used for collecting radon gas and the corresponding sampling locations in the Field Data Log Book. Note the ones placed over cracks or drains.
2. For each canister emplaced, note the dates and times of emplacement and retrieval and the initials of the instrument technologist.

13.11.6.2 Sample Counting

Equipment, apparatus, and supplies

The equipment, apparatus, and supplies indicated in Sect. 13.8, Onsite Gamma Spectrometry, is used for counting the charcoal canister.

Equipment set-up and operation

1. Follow the procedures (as applicable) in Sect. 13.8, Onsite Gamma Spectrometry, for setting up and operating the nuclear counting system.
2. Use Sect. 13.8.6.3, Onsite Gamma Spectrometry, steps 5 through 12, and substitute charcoal canister for soil sample.

Calculations

The radon flux is calculated from the gross count data using a computer program run on the Commodore Pet computer on the mobile laboratory. This program provides the appropriate decay corrections, background subtraction, etc., to result in an estimate of the flux in pCi/m^2-sec. The equation used in this determination is

$$\text{flux} = \frac{\text{Net Count} \times 1.59 \times 10^{-8}}{E \times 0.0872\,(1-e^{-\lambda t})\,(e^{-\lambda t_1} - e^{-\lambda t_2})},$$

where

E = calibration factor (Sect. 20.13, Calibration of Laboratory Gamma Spectrometry Systems),
λ = 7.55×10^{-3} h^{-1},
t = exposure period in hours,
t_1 = time between end of exposure and start of counting time,
t_2 = time from end of exposure to end of counting, hours.

Charcoal canister regeneration

After counting, collect the charcoal canisters for subsequent regeneration and calibration.

The canisters may be regenerated by flushing with 1,000 L of radon-free air and heating to 100°C in an oven with convection air flow, or they may be set aside for radon to decay.

Before reusing the charcoal canisters, they need to be recalibrated following Sect. 20.17, Calibration of Charcoal Canisters.

13.12 METEOROLOGICAL DATA COLLECTION

13.12.1 Purpose

The purpose of this procedure is to describe the methods for the collection of meteorological data which are used in conjunction with radiological measurements for the ORNL-RASA program.

13.12.2 Applicability

This procedure applies to the measurement of relative humidity which is used in the interpretation of radon measurements using Wrenn Chambers. Other meteorological data are not presently being obtained and therefore their collection procedure will be developed as the need arises.

13.12.3 References

Sect. 13.9, Radon Measurements

13.12.4 Definitions and Abbreviations

13.12.4.1 Definitions

RELATIVE HUMIDITY. The ratio of actual vapor pressure to the saturation vapor pressure over water at the air temperature during the humidity measurement.

Also see Sect. 1.5 of this manual, Terminology.

13.12.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

13.12.5 Responsibilities

13.12.5.1 Site Leader

The site leader is responsible for the implementation of this procedure.

13.12.5.2 Instrument Technologist

The instrument technologist who is responsible for radon concentration measurements using the Wrenn Chambers will also be responsible for the measurement of relative humidity. See Sect. 13.9, Radon Measurements.

13.12.6 Procedure

13.12.6.1 Instrument

Hygrometer

13.12.6.2 Relative Humidity Reading

1. Set the hygrometer near the Wrenn Chamber. See Sect. 13.9, Radon Measurements.
2. Let the hygrometer stabilize for at least 15 min before taking any readings.
3. Read the relative humidity and record the data in the Radon Data Log Book. The relative humidity will be used to correct radon measurements using Wrenn Chambers.

13.13 FIELD PHOTOGRAPHY

13.13.1 Purpose

The purpose of this procedure is to list photographic equipment required and to provide guidance in the selection of subject matter for site photographs.

13.13.2 Applicability

This procedure applies to all candidate site and vicinity property photography conducted in the ORNL-RASA program.

13.13.3 References

Canon Instruction Manual E

13.13.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

13.13.5 Responsibilities

The site leader is responsible for the implementation of this procedure, and the site leader or his designee is responsible for the production of photographs in accordance with this procedure.

13.13.6 Procedure

13.13.6.1 Equipment and Supplies

Camera	35mm SLR Canon A-1
Lenses	Canon FD 50mm 1:1.4, S.S.C., standard lens, Canon FD 24mm 1:2.8, wide angle lens, and Canon FD 80-200mm, 1:4, zoom lens
Flash	Speedlite 199A electronic flash and diffuser
Lens Hood	BS55 for standard lens; BW52C for wide angle lens
Filters	UV: 55mm for standard lens, 52mm for wide angle lens, 58mm for zoom lens PL: 55 0 for standard lens, 52mm for wide angle lens, 58mm for zoom lens
Miscellaneous	Carrying case, tripod

13.13.6.2 Technical Operation

The technical operation of photographic equipment is beyond the scope of this procedure, and it is assumed that the site leader or his designated team member has acquired the technical skills necessary to implement this procedure (e.g,, exposure control, lens selection and effect, etc.). The photographer will maintain a notebook in which photographic information is recorded, including: time, date, location, exposure, lens used, and any additional notes. These notes may be placed in the photography folder of the project file.

13.13.6.3 Subject Selection

General overview

The general purposes of site photography are to document as much information concerning a site as possible; to identify a site and special, unique or peculiar characteristics of the site; and to document particular areas of interest determined during the radiological survey.

Site photography should begin during the preliminary survey and continue through all phases of the program, as required, to the completion of the work on a site.

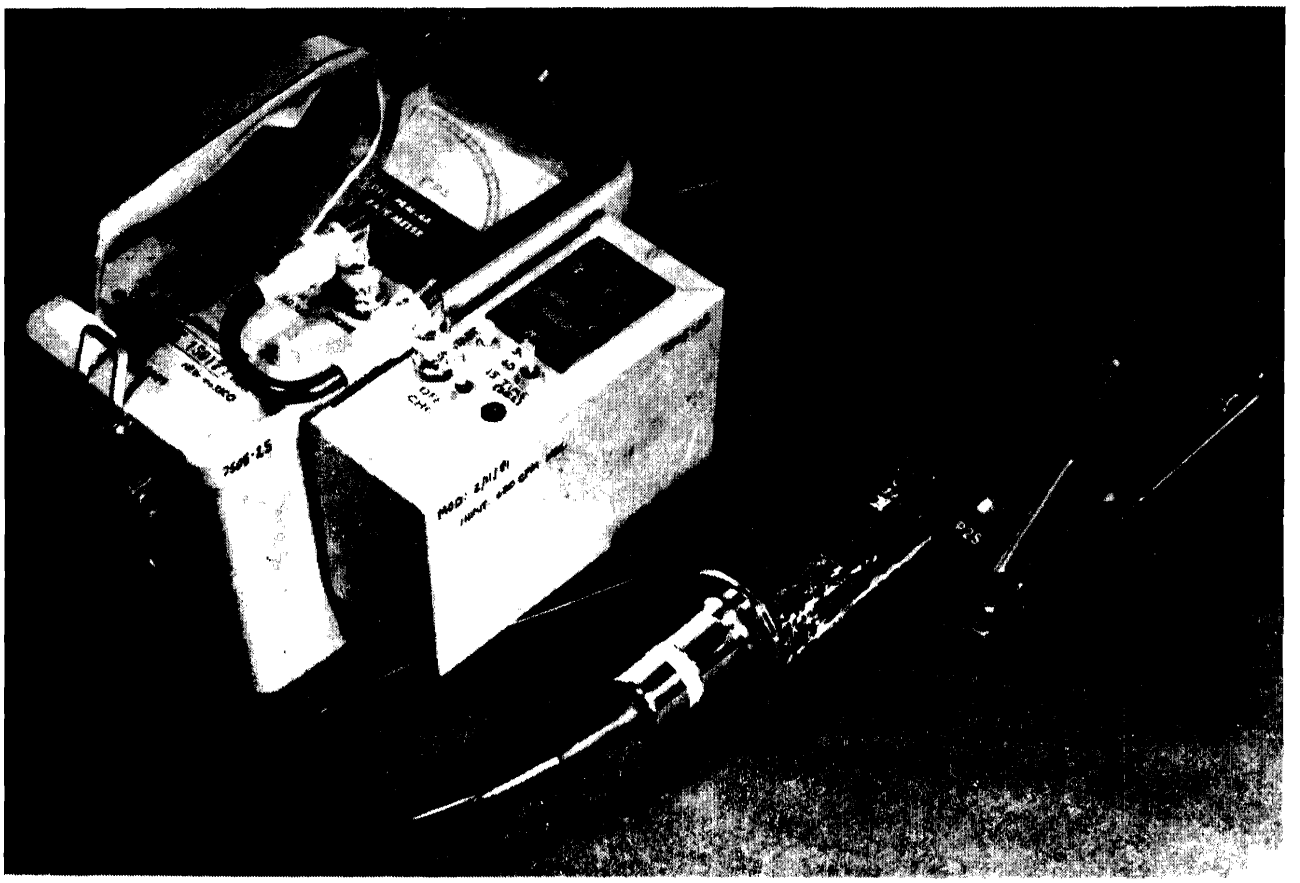
Photography procedure

1. Photograph general site outdoor views of the property from as many points as required to provide a reasonable understanding of the property, including relative size, structures, and terrain.
2. Walk over the outdoor areas of the property and photograph detail views including, but not limited to, building exteriors and specific terrain obstacles (streams, fences, rubble, brush, etc.).
3. Photograph general structure interior views (from at least two locations) to document all structure interiors, walls, and contents. Photograph details and contents of structure interiors.
4. Detail consideration should be given to areas which may require special contractor work (brush, debris or equipment removal, etc.) or may present unusual problems to the contractors and/or the survey team during the performance of the radiological survey. Damaged property (cracked driveways, etc.) which may potentially be the source of damage claims by the property owner following the survey should also be documented at this time in the "as found" condition.
5. During the preliminary site radiological survey, photograph all locations of radioactive hot spots. Coordination with the instrument technologist is required to determine the areas requiring photographic coverage.
6. During subsequent site visits/surveys, photographically document all unusual findings, conditions, and/or contractor work as required.

13.13.6.4 Log Book Entries

None. Notebook required per Sect. 6.2 of this procedure.

Exhibit 13.1. Eberline PRM-4A count rate meter and probe.



SUBJECT: FIELD MEASUREMENTS

Exhibit 13.2. Indoor data sheet.

TX-5123

INDOOR DATA SHEET

INSTRUMENTS: _____

PIC LOCATION: _____

μR/hr: _____

OWNER: _____

ADDRESS: _____

PAGE ____ OF ____

DATE: _____

SURVEYORS: _____

ROOM NO.	γ MEASUREMENTS			β-γ MEASUREMENTS		α MEASUREMENTS			SMEAR NO.	REMARKS
	CENTER OF RM. 1 METER/ SURFACE (10^3 CPM)	SCAN RANGE (10^3 CPM)	LOCATION OF MAXIMUM γ	CENTER OF ROOM FLOOR (CPM) OPEN/ CLOSED	LOCATION OF MAX. γ (CPM) OPEN/ CLOSED	WALLS & FLOOR CTS./ ____	MAXIMUM α CTS./ ____	LOCATION OF MAXIMUM α		

Exhibit 13.3. Model PAC-4G portable gas proportional alpha counter.

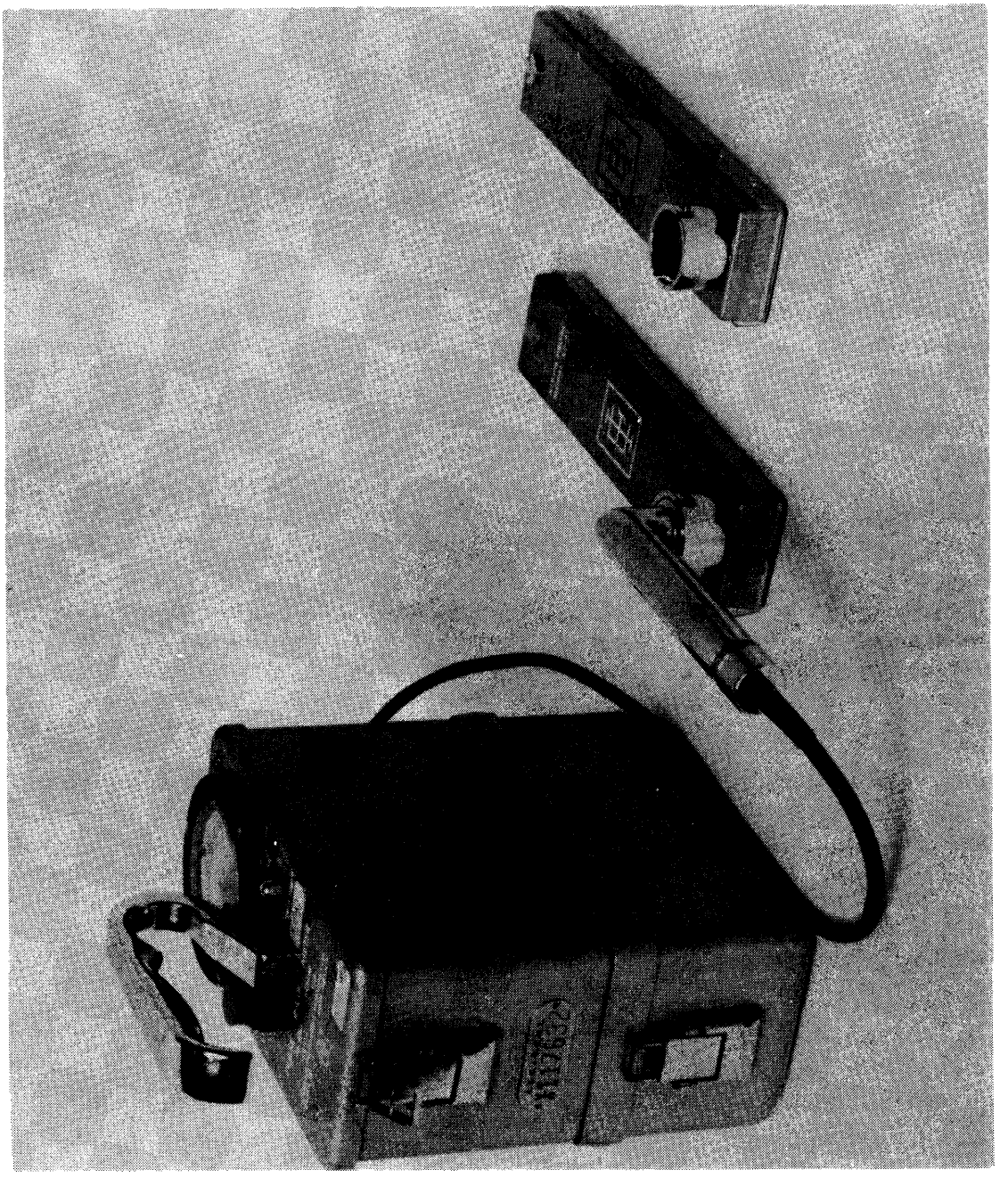


Exhibit 13.4. Eberline E120/120G Geiger counter.

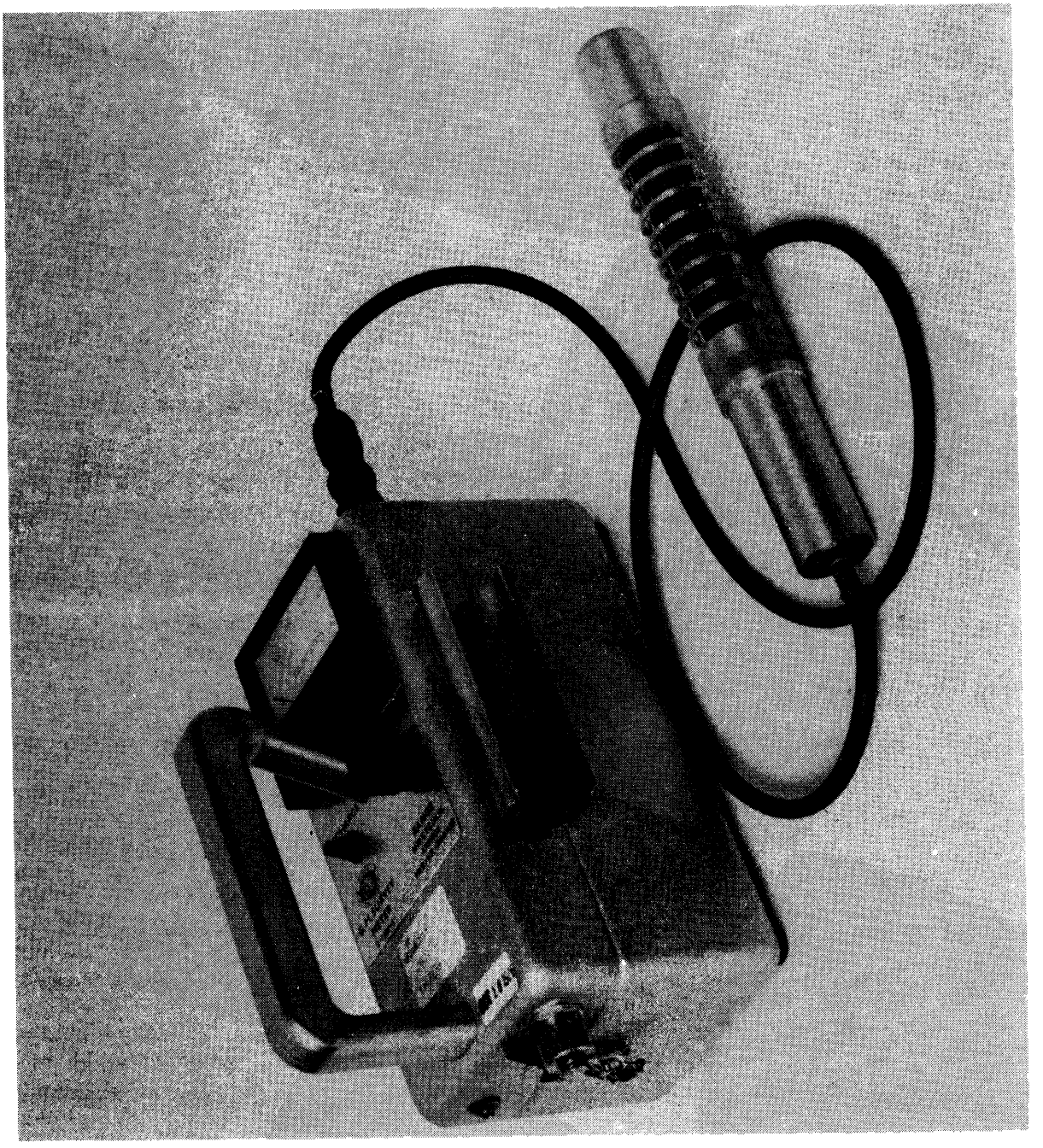
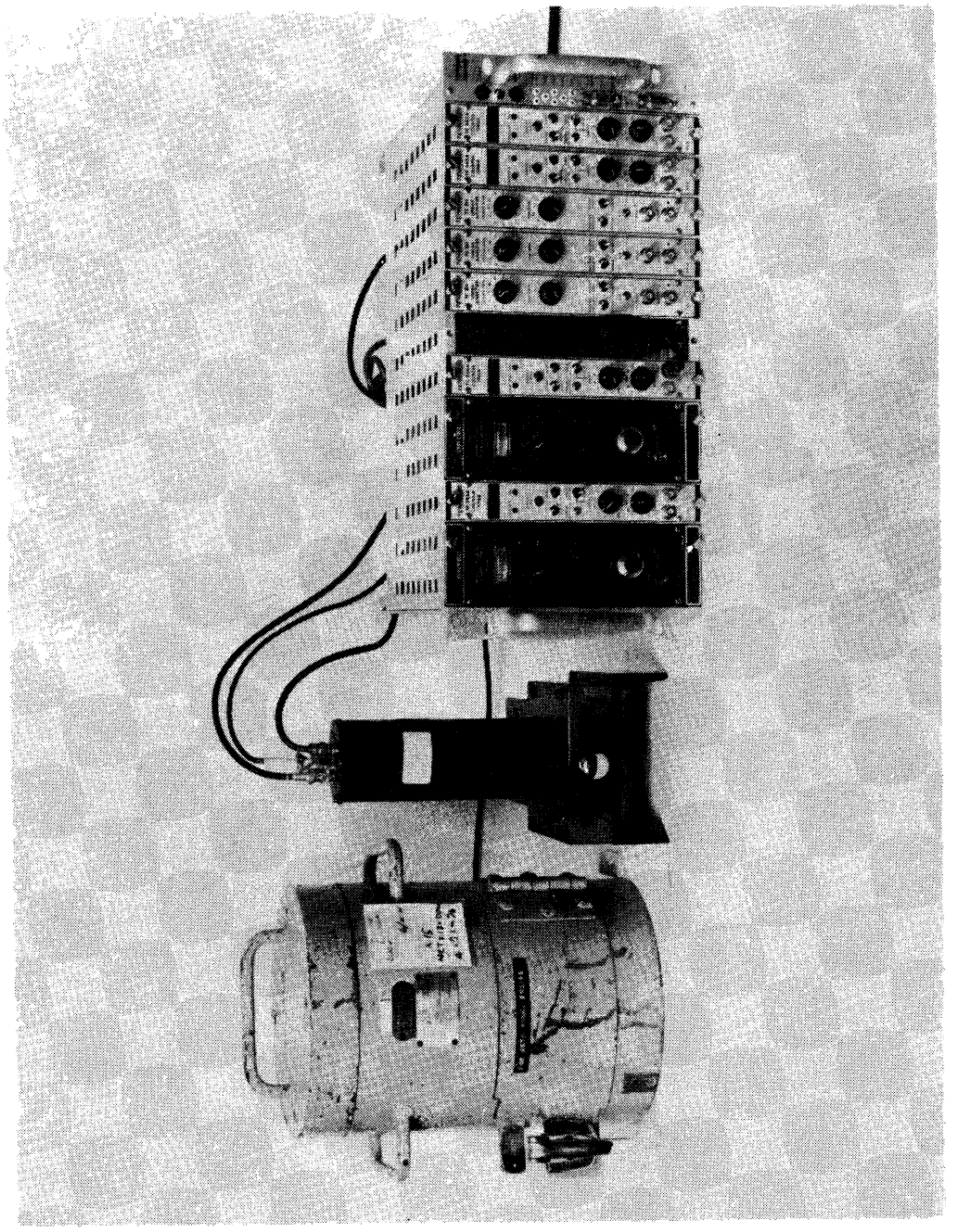


Exhibit 13.5. Smear counters and associated electronics (the beta counter is on the left and the alpha is on the right).



SUBJECT: FIELD MEASUREMENTS

Exhibit 13.6. Smear sample data sheet.

SMEAR SAMPLE DATA

AME (HP&S)	PHONE	BLDG. NO. (HP&S)	LOCATION (SMEARS TAKEN)	DATE
MEARS NUMBERED: From To	RESULTS REQUIRED: Date Time		DATE COUNTED	COUNTER OPERATOR
IVE D/M ONLY ON SMEARS OVER: _____ d/m α _____ d/m β	REMARKS:			

α	β	LOCATION (*)	α	β	LOCATION (*)	α	β	LOCATION (*)
1			34			67		
2			35			68		
3			36			69		
4			37			70		
5			38			71		
6			39			72		
7			40			73		
8			41			74		
9			42			75		
10			43			76		
11			44			77		
12			45			78		
13			46			79		
14			47			80		
15			48			81		
16			49			82		
17			50			83		
18			51			84		
19			52			85		
20			53			86		
21			54			87		
22			55			88		
23			56			89		
24			57			90		
25			58			91		
26			59			92		
27			60			93		
28			61			94		
29			62			95		
30			63			96		
31			64			97		
32			65			98		
33			66			99		

UCN-1632 (*) *Give only if required.*
7-67)

Exhibit 13.7. Pressurized ion chamber.

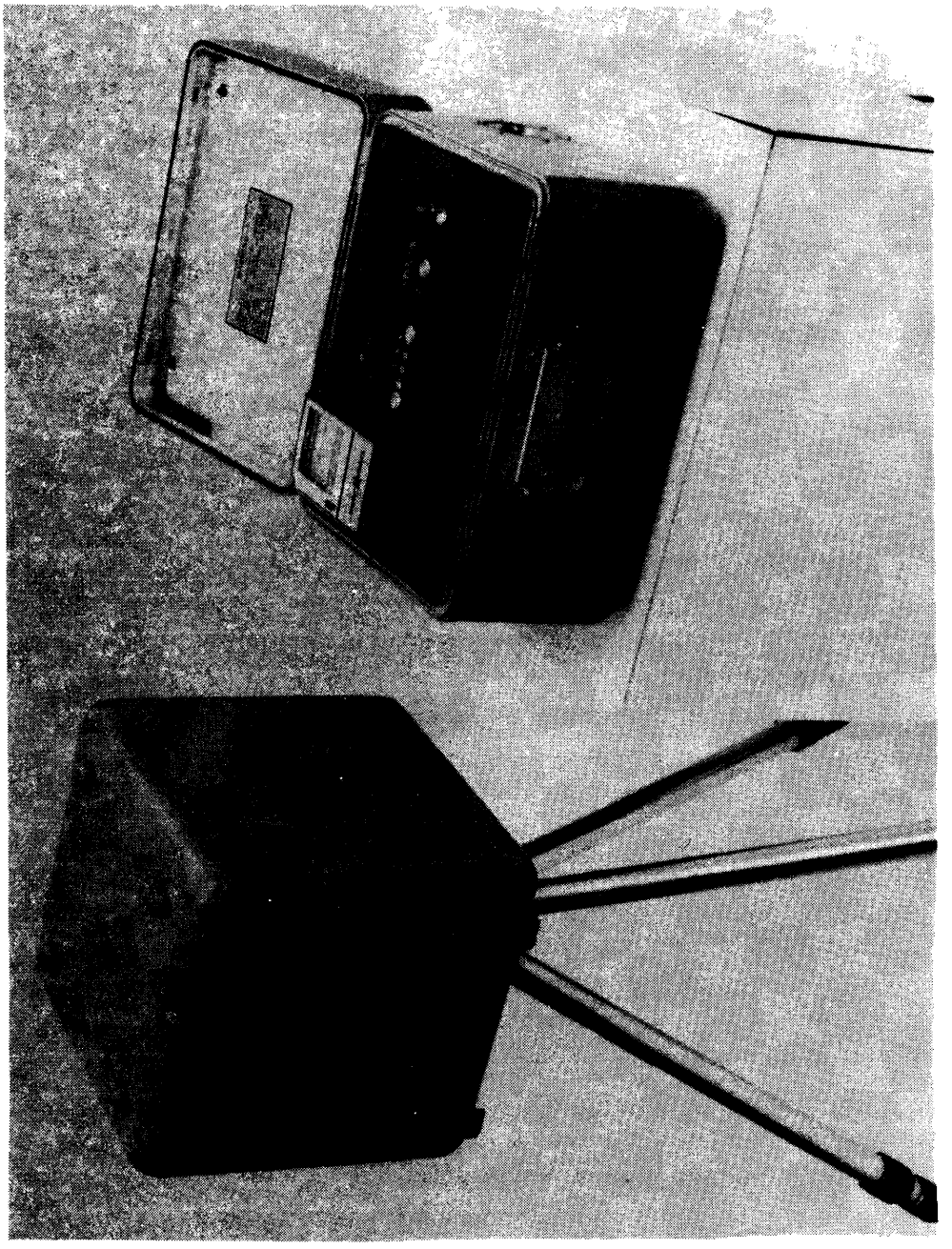
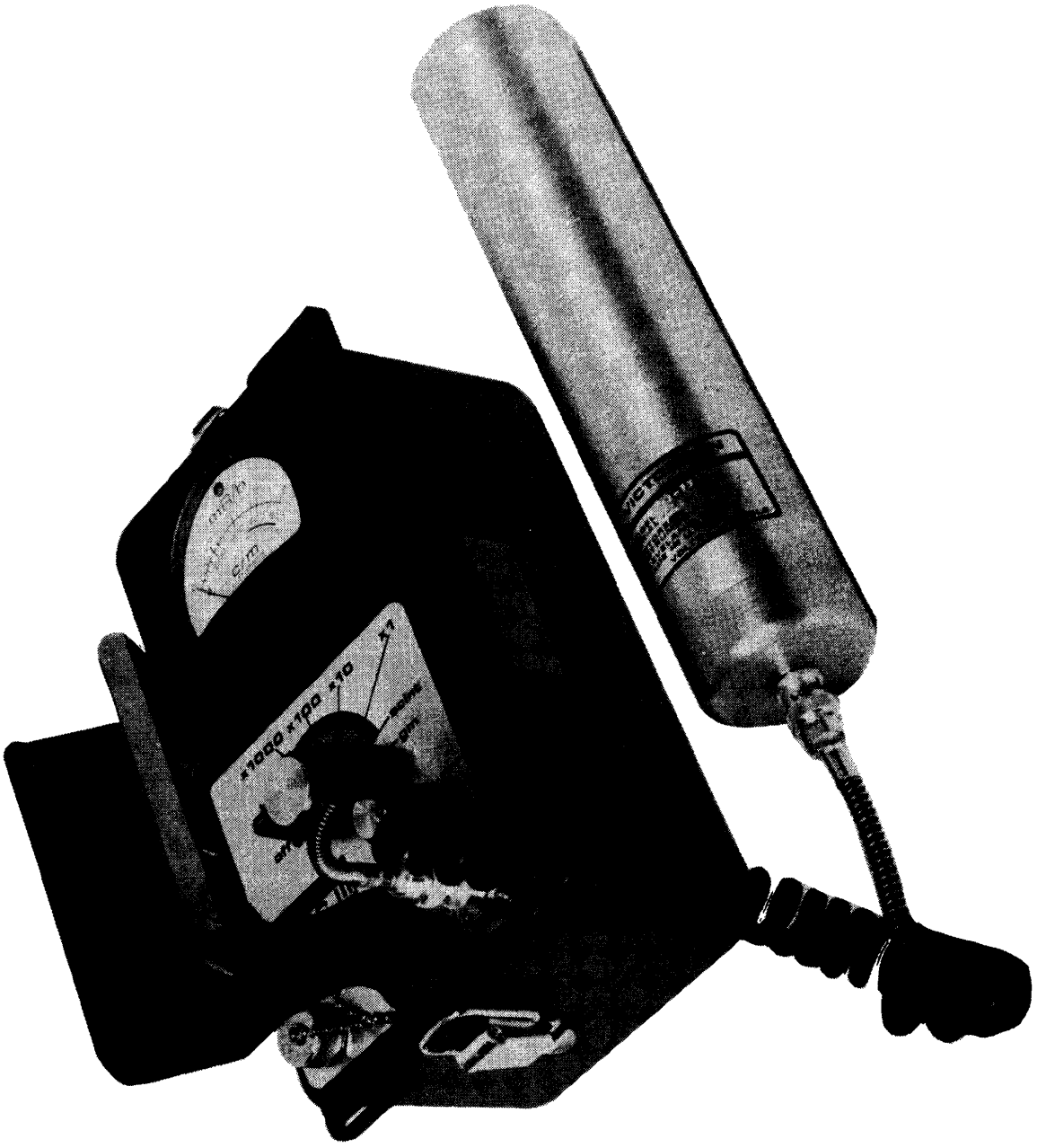


Exhibit 13.8. Victoreen portable ratemeter, Model 490 Thyac III.



SUBJECT: FIELD MEASUREMENTS

Exhibit 13.9. Outdoor data sheet.

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

OUTDOOR DATA SHEET

PAGE ___ OF ___

DATE: _____ INSTRUMENTS: _____ SURVEYORS: _____

PROPERTY: _____

GRID POINT or BLOCK (CIRCLE ONE)	GRID POINT READINGS γ SCINT. (10^3 CPM) 1 METER	SURFACE	γ-SCAN RANGE (10^3 CPM)	ANOMALIES W/LOCATION of MAX. γ	GRID BLOCK MAX γ 10^3 CPM 1m / SURFACE	β-γ CPM OPEN / CLOSED	SOIL SAMPLE NO.	REMARKS

Exhibit 13.10. Hole logging equipment.

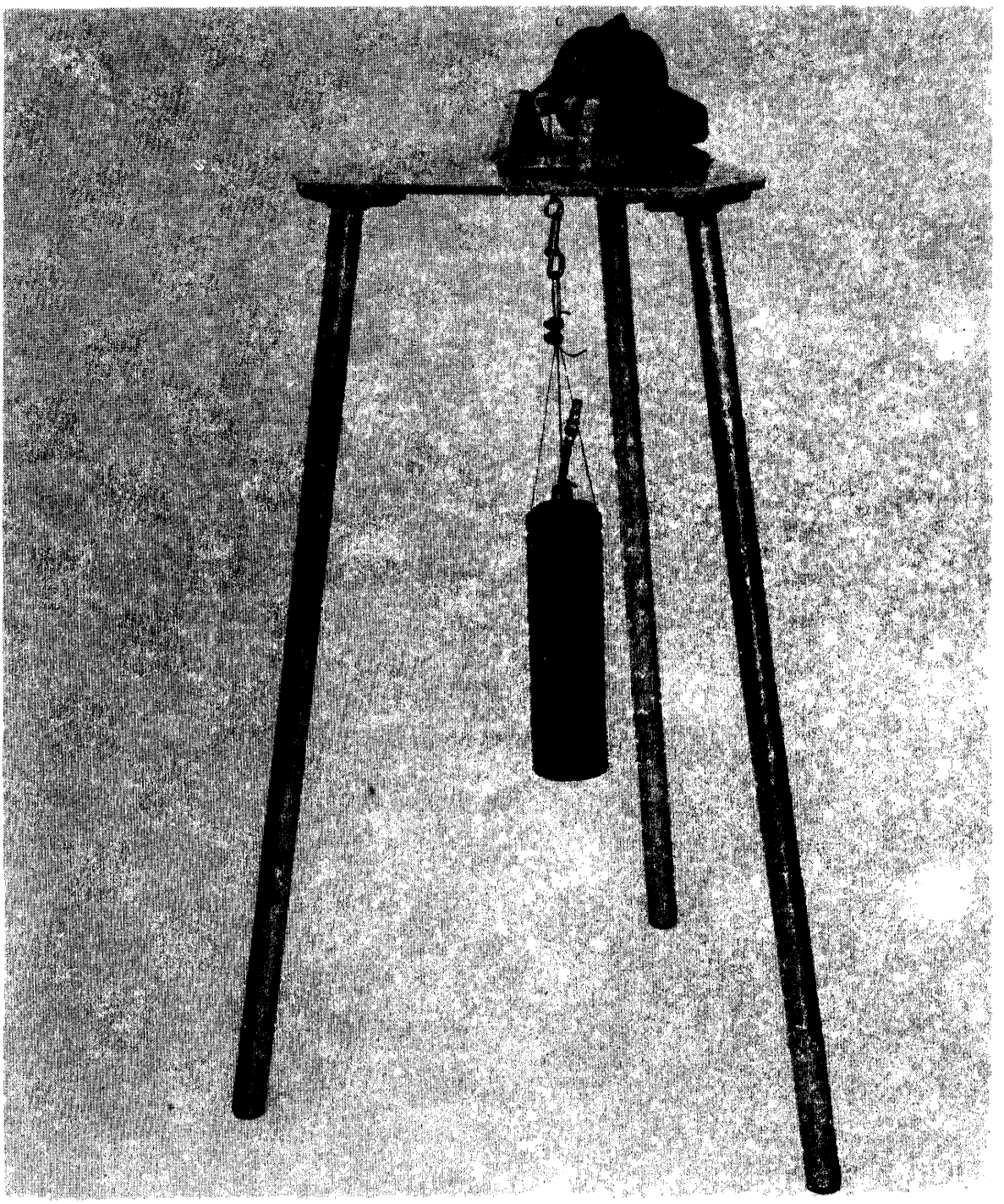


Exhibit 13.11. Hole logging instrumentation.

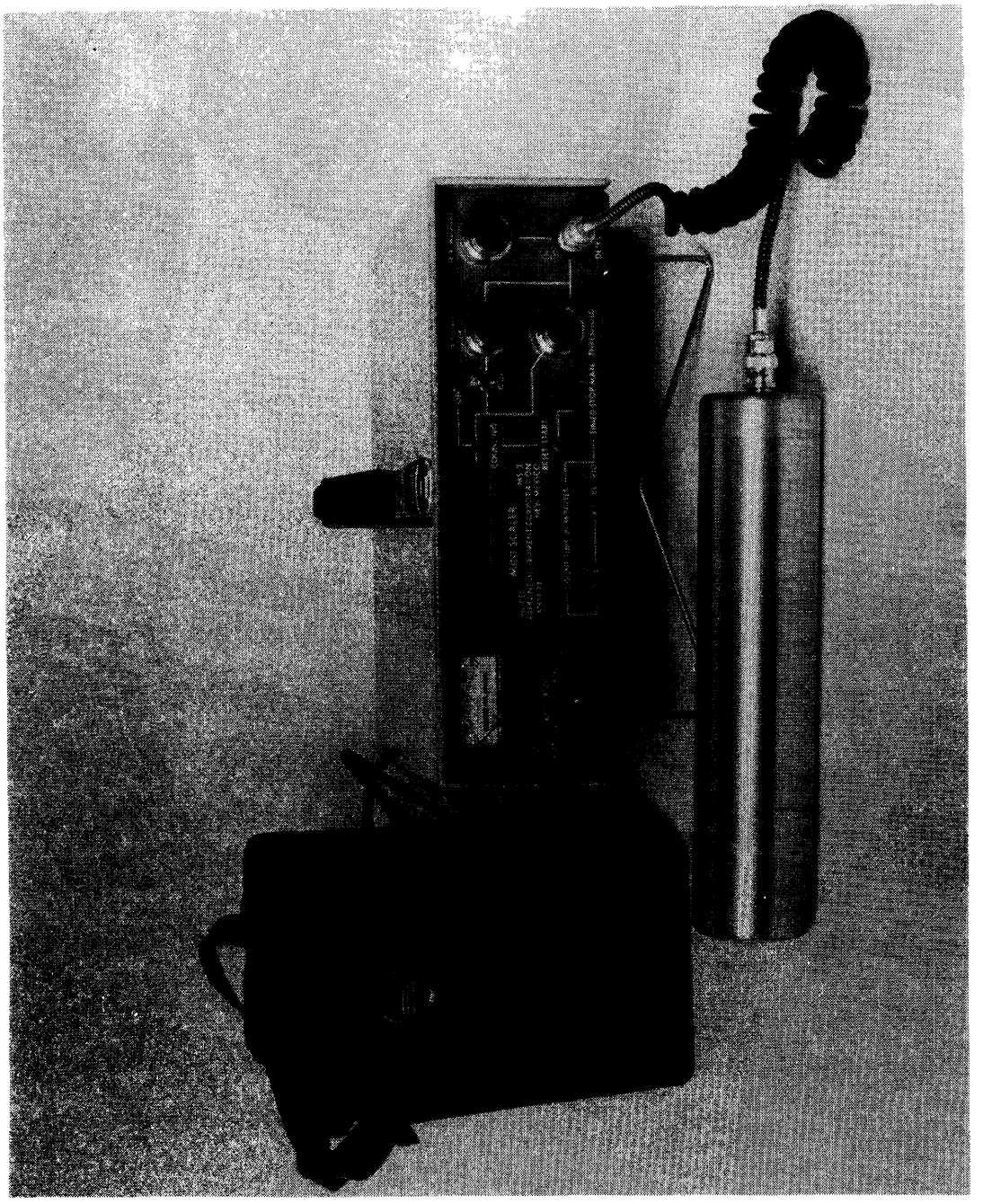


Exhibit 13.12. Hole logging and sample data sheet.

OFFSITE MEASUREMENTS, OAK RIDGE NATIONAL LABORATORY

HOLE LOGGING AND SAMPLE DATA SHEET

DATE: _____ SURVEYORS: _____

PROPERTY: _____ INSTRUMENTS: _____

HOLE NO. _____ GRID LOCATION. _____					HOLE NO. _____ GRID LOCATION. _____				
γ SCINT. LOGGING DATA			SAMPLE NO.	SAMPLE DEPTH( )	γ SCINT. LOGGING DATA			SAMPLE NO.	SAMPLE DEPTH( )
DEPTH( )	SHIELDED CTS/	UNSHIELDED CTS/			DEPTH( )	SHIELDED CTS/	UNSHIELDED CTS/		

SUBJECT: FIELD MEASUREMENTS

Exhibit 13.13. Component list for onsite gamma spectrometry system.

EQUIPMENT

Eve

1 - Tracor Northern TN 1314 Display Unit
1 - Tracor Northern TN 1706 Pulse Height Analyzer
1 - ORTEC 490B Linear Amplifier
1 - ORTEC 456 High Voltage Power Supply
1 - Tennelec Tennebin 3 Nimbin Power Supply

Adam

1 - Nuclear Data ND 100 Pulse Height Analyzer
1 - Nuclear Data ND 100 Pulse Height Digital Tape Recorder
1 - ORTEC 490B Linear Amplifier
1 - ORTEC 456 High Voltage Power Supply
1 - Tennelec Tennebin 3 Nimbin Power Supply
1 - NaI Photomultiplier/Detector System

Additional Equipment (Adam & Eve)

1 - ORTEC 490B Linear Amplifier
1 - ORNL Low Voltage 85 VDC Power Supply
2 - Diode Detectors

These additional components may be used to configure the system for radon daughter counting.

Exhibit 13.14. ADAM spectrometer system photograph.

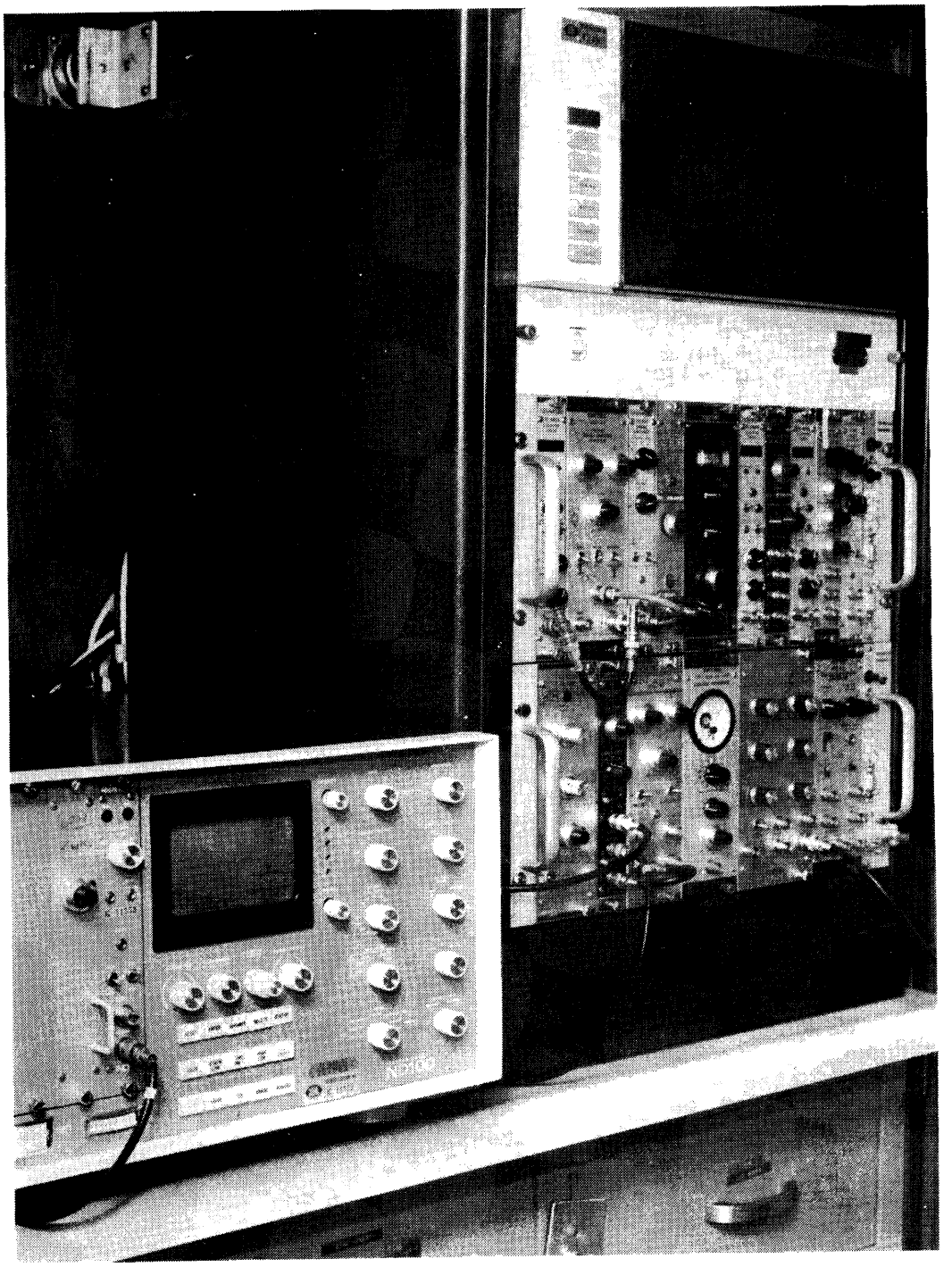


Exhibit 13.15. EVE spectrometer system photograph.

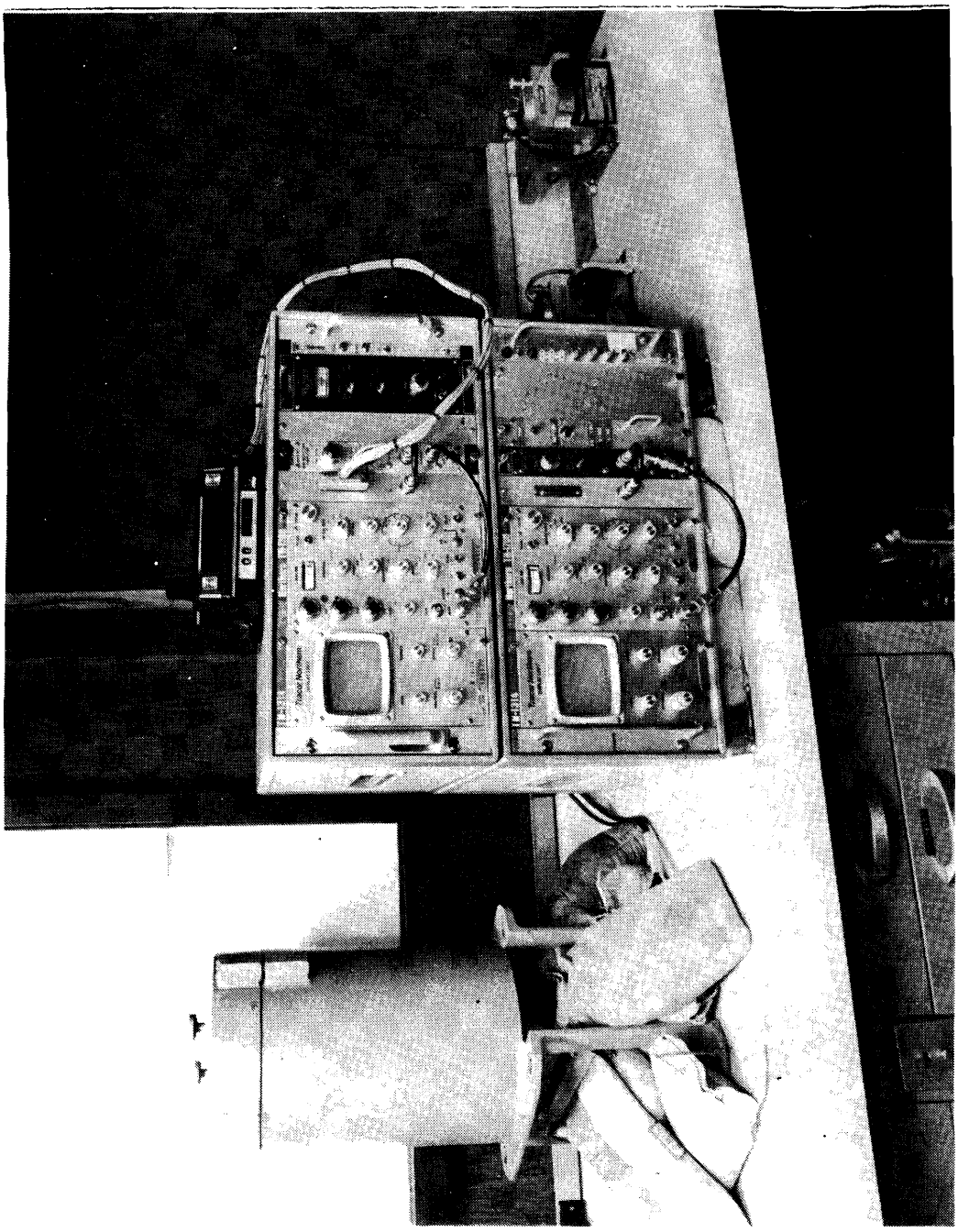


Exhibit 13.16. Wrenn chambers on top of counting system.

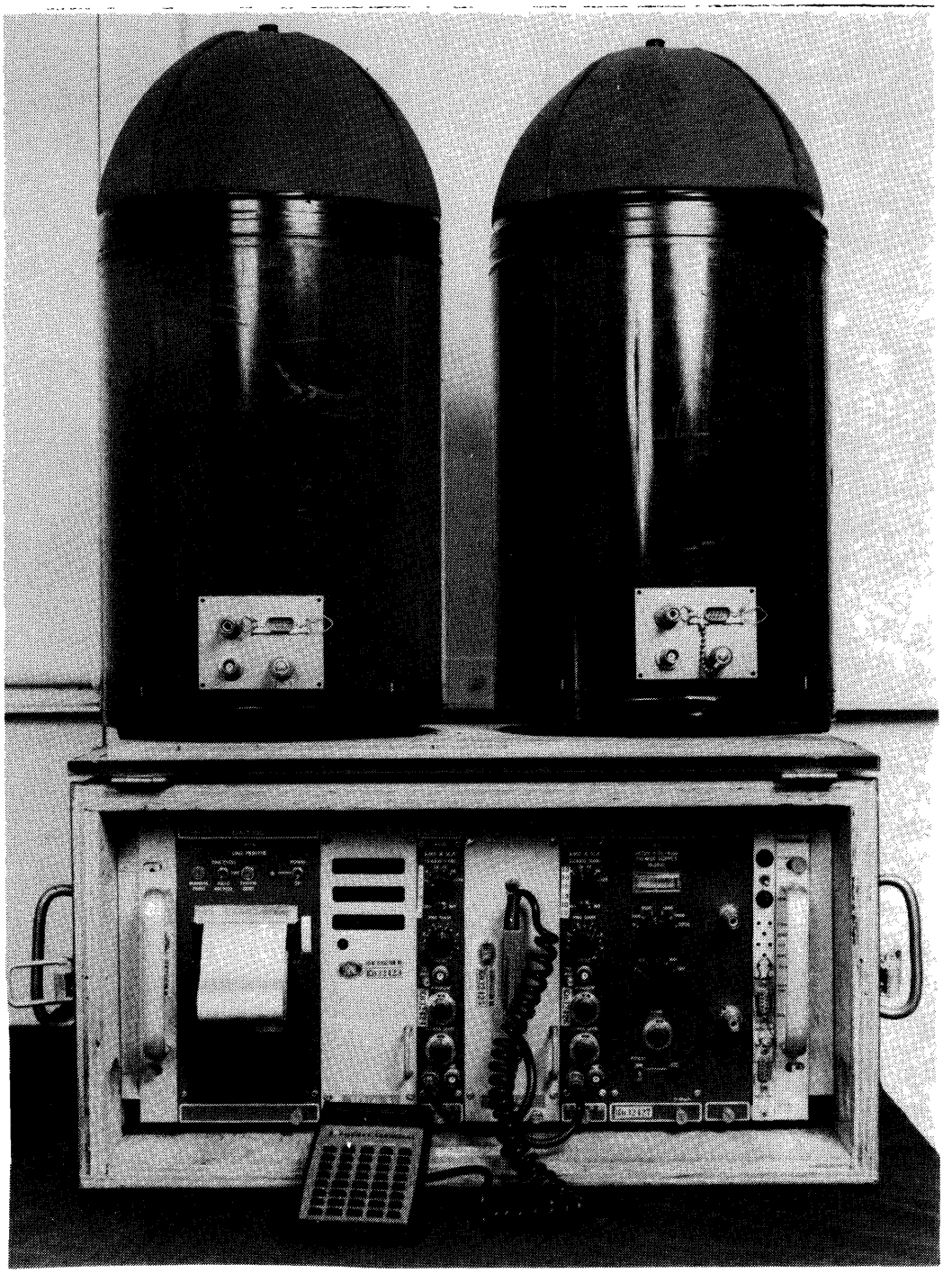


Exhibit 13.17. Lucas cell.

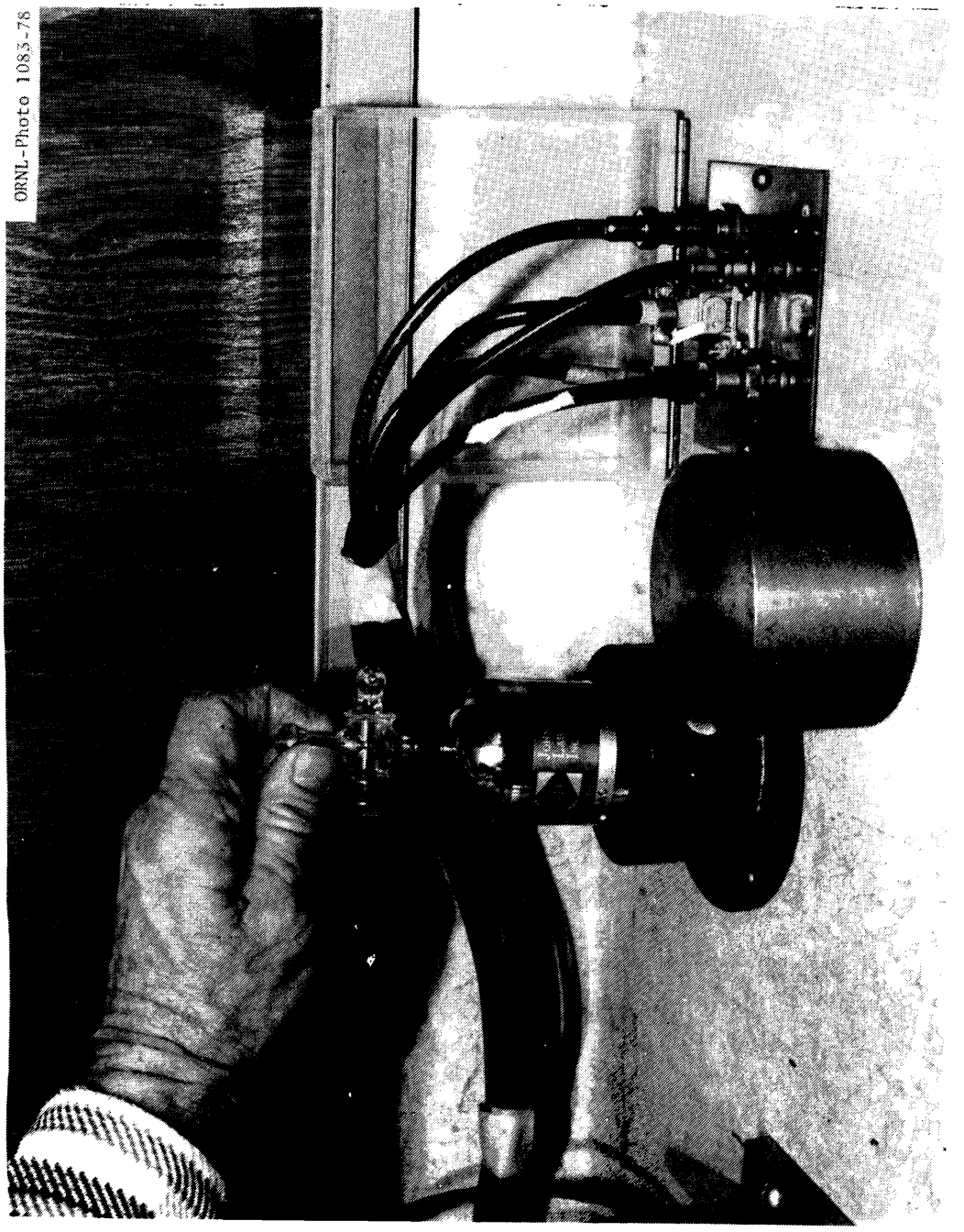
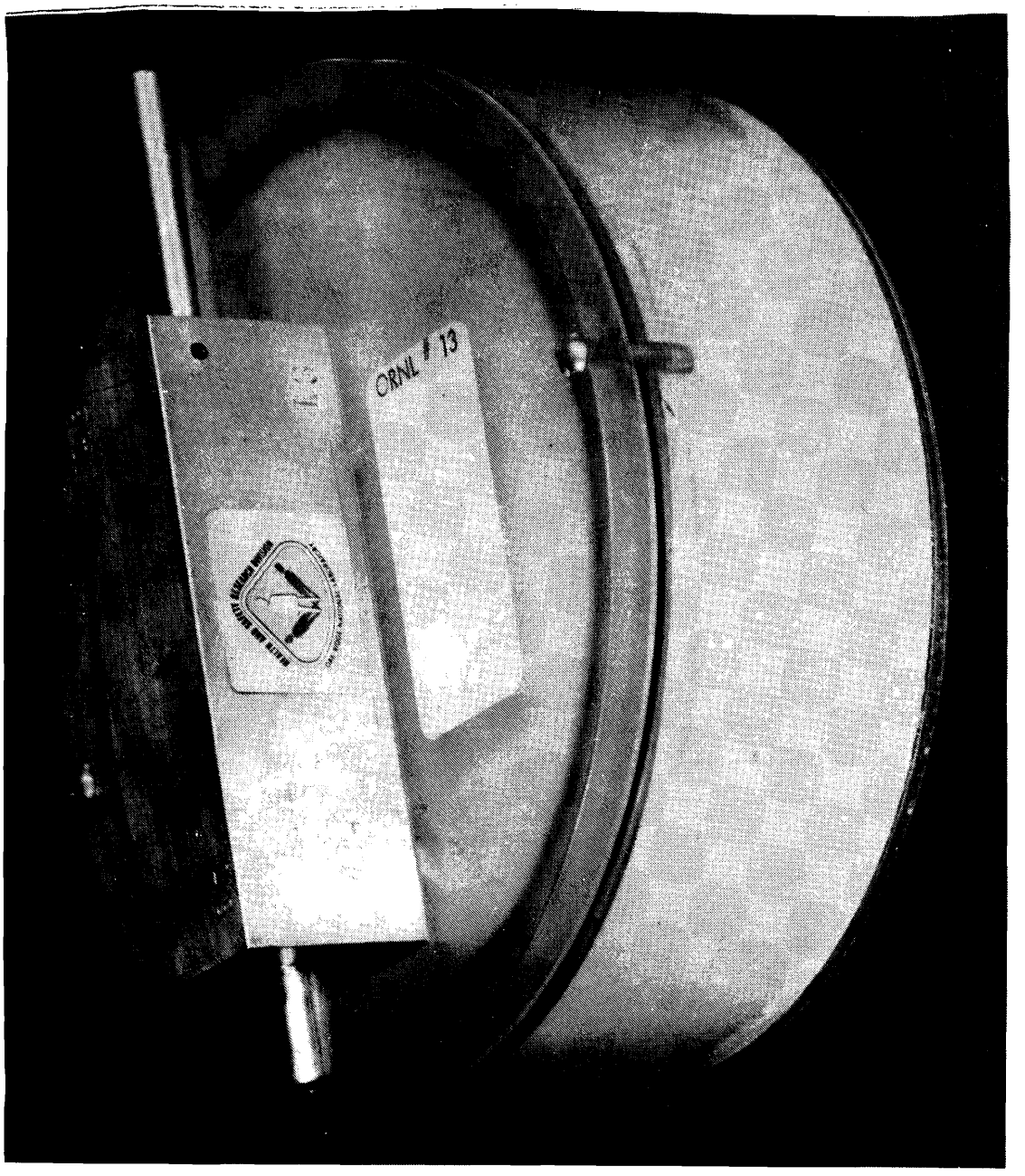


Exhibit 13.18. ORNL cell.



SUBJECT: FIELD MEASUREMENTS

Exhibit 13.19. Cassette tape.

Technologist action	CRT Display	Function or comment
1. Turn on PET or Commodore Computer (switch is located at rear left side)		
2. Load the tape on the cassette player and rewind to the beginning of tape		
3. Type LOAD "*", 8. Push RETURN key		
4. Push PLAY button on cassette player	READY	
5. Type RUN. Push RETURN key		Loads the DOS Support System
6. Type in program desired. Example - /"LUCAS CELLS". Push RETURN key	Searching for Lucas Cells Loading Lucas Cells Ready	
7. Type RUN and push RETURN key		The computer will start asking for pertinent information
8. Provide information inputs as requested by computer.		

Exhibit 13.20. Low volume air sampler.

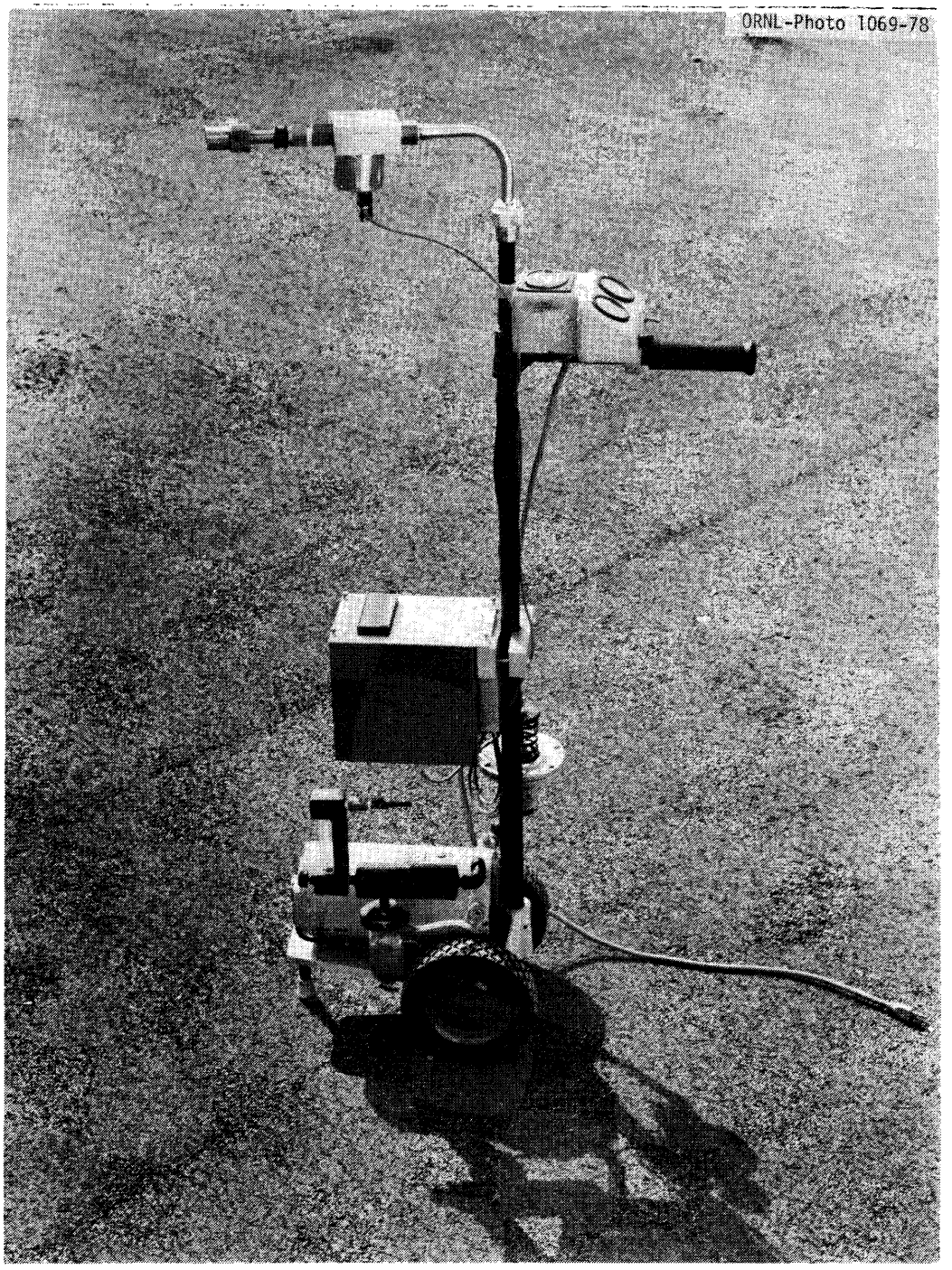


Exhibit 13.21. Counting system for air samples.

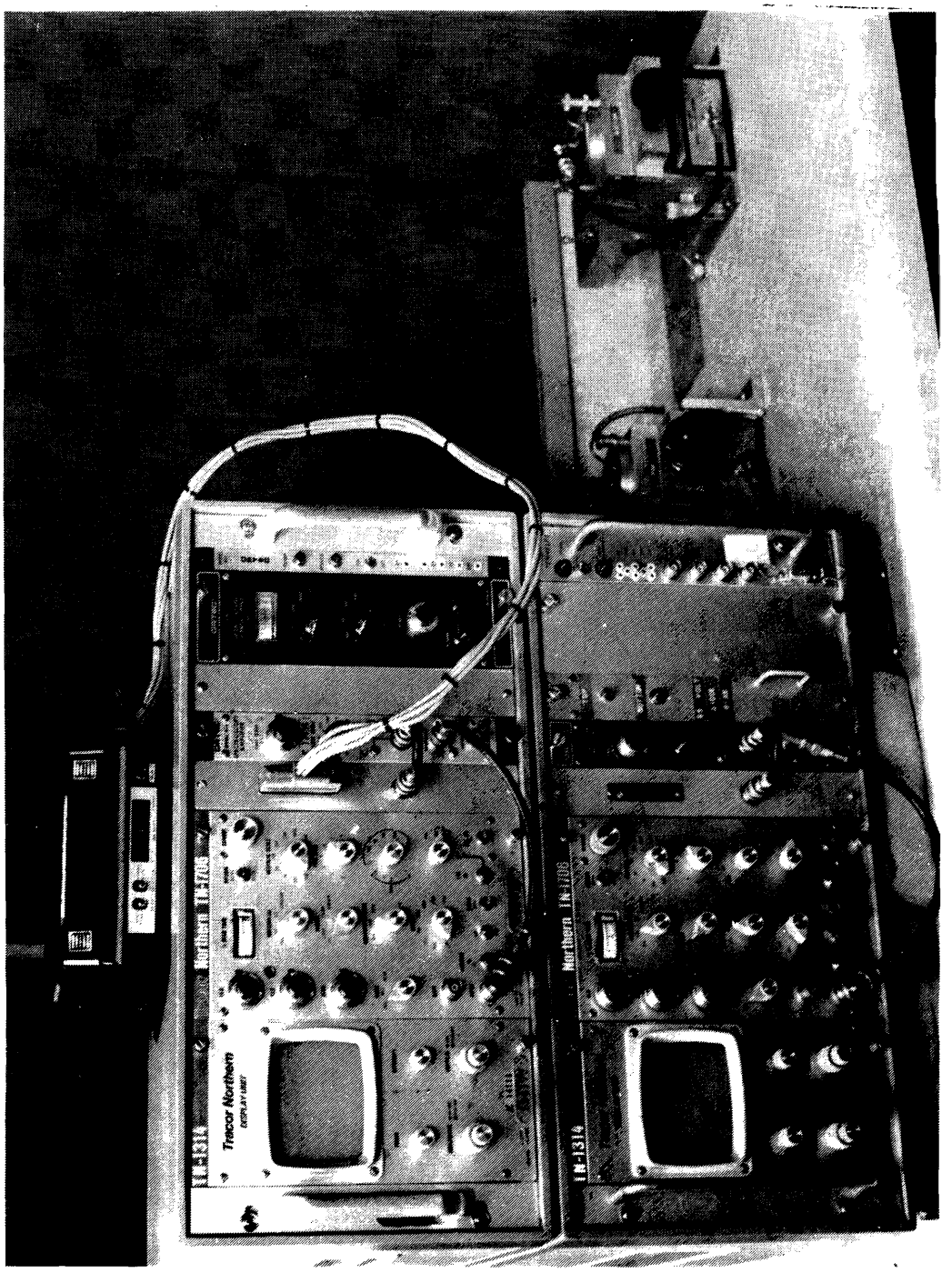


Exhibit 13.22. Sample filter holder/detector.

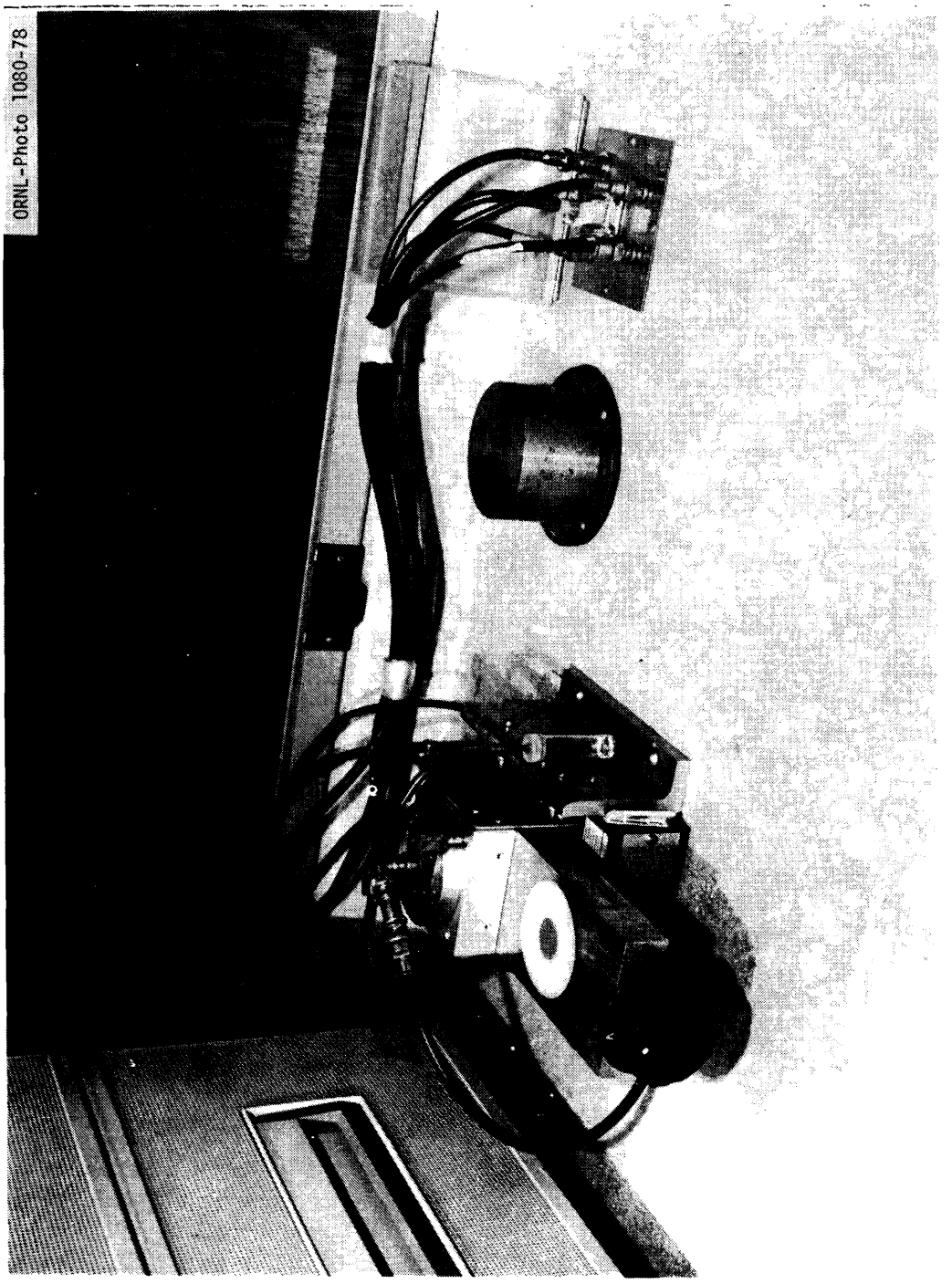


Exhibit 13.23. Charcoal canister.

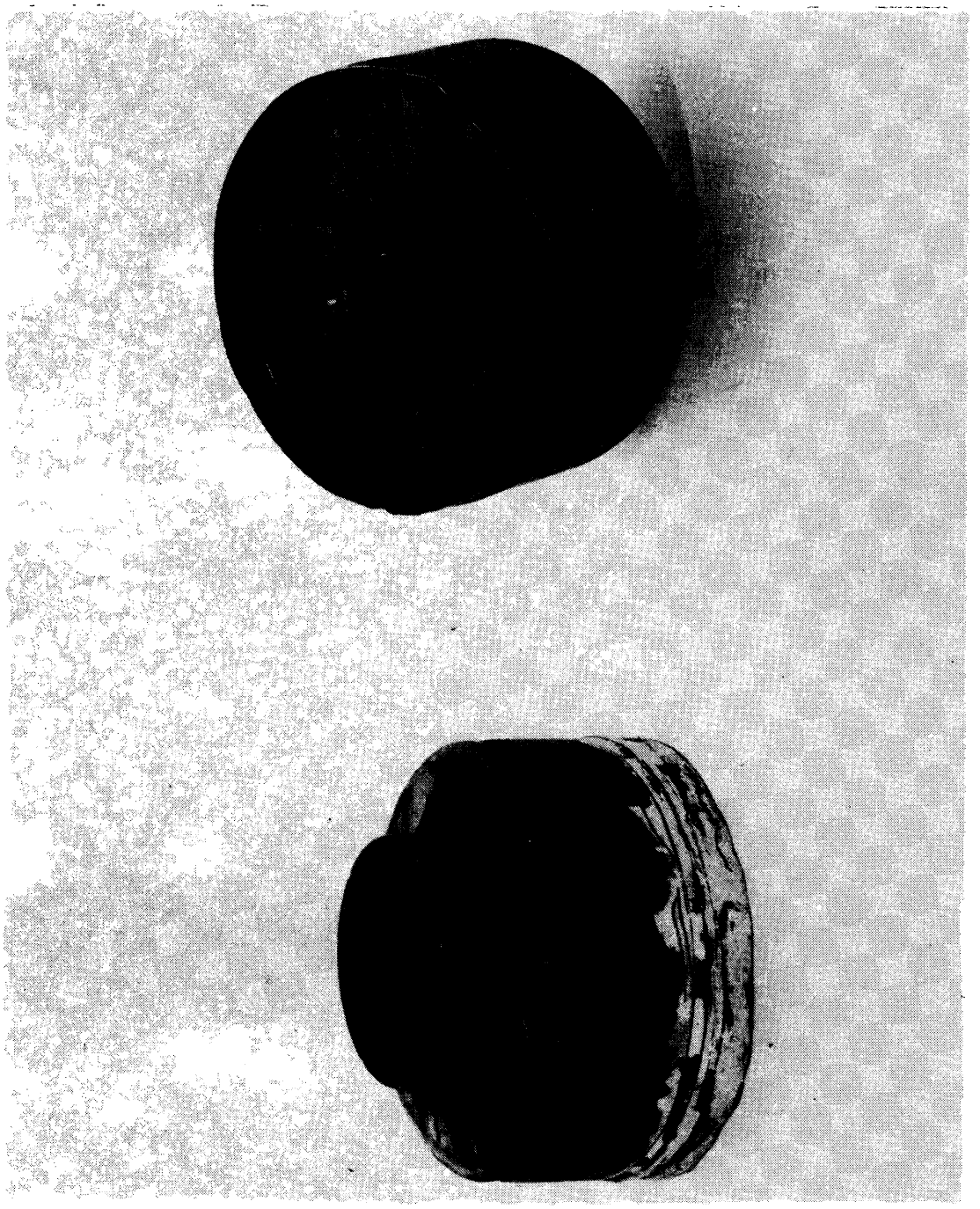
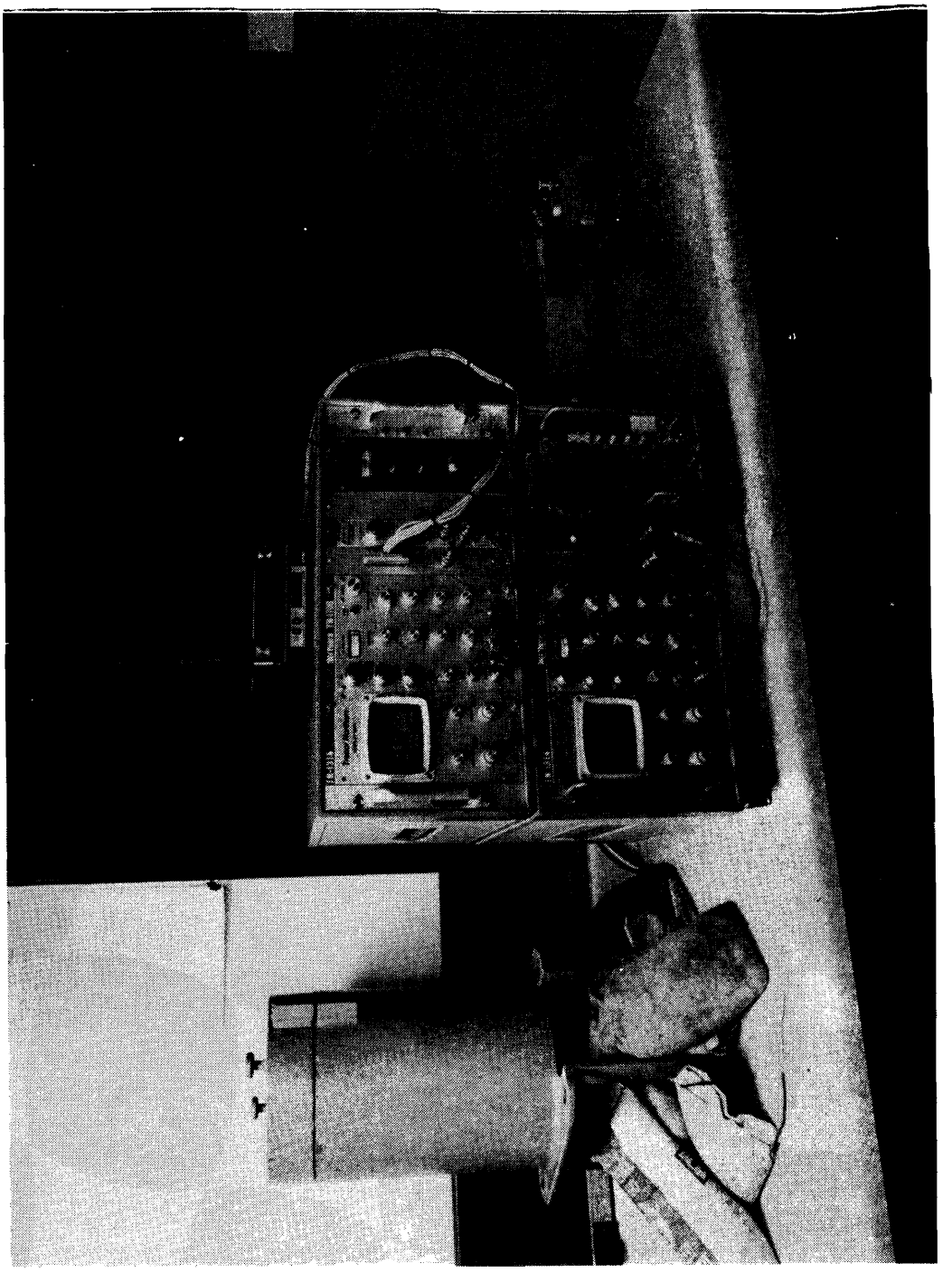


Exhibit 13.24. Charcoal counting system.



14. SAMPLE COLLECTION

14. SAMPLE COLLECTION

14.1 SOIL AND SEDIMENT SAMPLE COLLECTION

14.1.1 Purpose

The purpose of this procedure is to establish the guidelines for collecting soil and sediment samples at survey sites.

14.1.2 Applicability

This procedure applies topsoil and sediment sample collections at all survey sites by ORNL-RASA personnel.

14.1.3 References

1. Sect. 14.6, Packaging and Shipment of Environmental Samples
2. Sect. 14.8, Sample Identification and Labeling

14.1.4 Definitions and Abbreviations

SURFACE SOIL. The top 6 in. below the surface. For sampling beneath driveways or parking lots, surface soil begins where the driveway or parking lot covers end.

SUBSURFACE SOIL (shallow). Soil at depths greater than 6 in. below the surface level.

SEDIMENT. The portions of solid materials deposited below a surface water body.

BIASED SAMPLE. A sample taken from a location of known characteristics, especially those of high radioactivity.

COMPOSITE SAMPLE. A sample comprised of aliquots of soil from a number of specified locations, used for determining average soil concentrations for an area.

SYSTEMATIC SAMPLE. A sample taken at systematic locations from a survey site.

Also see Sect. 1.5 of this manual, Terminology.

14.1.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

14.1.5 Responsibilities

14.1.5.1 Site Leader

The site leader is responsible for the implementation of this procedure at the survey site.

14.1.5.2 Instrument Technologist

The instrument technologist is responsible for collection of soil and sediment samples in accordance with this problem.

14.1.6 Procedure

14.1.6.1 Locations

The site leader will specify the sampling locations at the survey site. Those locations cannot be determined beforehand. Specific sampling locations are normally designated as a result of radiation surveys performed at the site. This is particularly true of open fields, private buildings, and residences where previous detailed radiation surveys do not exist.

14.1.6.2 Types of Samples

There are normally two types of samples taken, systematic and biased. Composite samples can be derived from the random samples, if desired.

Systematic samples

Random samples are taken from a survey site. The site leader will determine the number and locations of the samples. Systematic samples are normally taken from the surface.

Biased samples

Biased samples are taken from locations of abnormally high radioactivity levels (greater than two times background levels). Biased samples are normally obtained at different depths at specific locations.

14.1.6.3 Sampling Equipment

Soil and sediment sampling equipment consists of simple implements such as gardening trowels, post hole diggers, or any implement that can be used for this purpose. For augered hole soil sampling, any implement that can take hole-side soils without being contaminated with soils from other depths of the hole may be used.

14.1.6.4 Sample Size and Packaging

Soil and sediment samples are obtained in approximately 64-in.^{3} volumes and packaged in plastic bags (see Sect. 14.6, Packaging and Shipment of Environmental Samples). They are then given an identification number and so labeled (see Sect. 14.8, Sample Identification and Labeling). The samples collected are temporarily stored in a bucket in the field. The samples are later transferred to the mobile laboratory for subsequent shipment to ORNL.

14.1.6.5 Soil and Sediment Sample Shipment

Soil and sediment samples are analyzed at the ORNL-RASA laboratory. They are, therefore, shipped from the site for this purpose. Refer to Sect. 14.6, Packaging and Shipment of Environmental Samples, for requirements for packaging and shipping of the samples.

14.2 WATER SAMPLE COLLECTION

14.2.1 Purpose

The purpose of this procedure is to provide guidelines for collecting water samples from survey sites.

14.2.2 Applicability

This procedure applies to the collection of water samples from RASA sites being surveyed by ORNL-RASA personnel.

14.2.3 References

1. Sect. 14.6, Packaging and Shipment of Environmental Samples
2. Sect. 14.8, Sample Identification and Labeling
3. Sect. 15.3, Determination of Radionuclides in Water Samples

14.2.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

SUBJECT: SAMPLE COLLECTION

14.2.5 Responsibilities

14.2.5.1 Site Leader

The site leader is responsible for the implementation of this procedure.

14.2.5.2 Team Member

The team member designated to collect water samples will do so according to this procedure.

14.2.6 Procedure

14.2.6.1 Sampling Location

Water samples are taken from locations with water bodies suspected of being contaminated by radioactive sources from the survey sites. Water sources can be surface water such as lakes, rivers, streams, etc., or subsurface water such as from wells or augered holes.

Specific sampling locations, if not already designated in the survey plan, will be determined by the site leader.

Water samples may be taken from any augered hole found to contain water.

14.2.6.2 Equipment and Apparatus

1. 1-1 polyethylene bottles with caps
2. Plastic funnel
3. Filter paper to fit funnel
4. Waterproof ink marking pen
5. Ladle or sample scoops

14.2.6.3 Sample Identification and Documentation

All bottles to be used for water samples will be numbered according to Sect. 14.8, Sample Identification and Labeling. These identification numbers will be recorded in the Field Data Log Book. Later, as each sample is collected, the sample type, location, time, date, and initials of sample collectors should also be entered in the log book.

14.2.6.4 Sample Collection

Surface water

Obtain surface water samples by dipping the polyethylene bottle directly into the water body, rinsing the bottle first with the water to be sampled. Avoid collecting solids with the water by using a cloth filter. If the water body is not deep enough, use the ladle or scoop with the funnel for obtaining the samples.

Subsurface water

Obtain subsurface water samples by any necessary means. The site leader may have to assess the situation first and improvise the sampling tools needed to obtain the subsurface water samples. If samples are from augered holes, filtering after collection may be required to minimize solids in the sample.

Precipitation

Precipitation is not presently sampled for analysis. The procedure for sampling precipitation will be developed when the need arises.

14.2.6.5 Sample Pretreatment

If sample pretreatment is required for the water samples collected, follow the instructions in Sect. 15.3, Determination of Radionuclides in Water Samples.

14.2.6.6 Sample Packaging and Shipping

Water samples are shipped from the survey sites to the Analytical Chemistry Division of ORNL for analyses. Follow the instructions in Sect. 14.6, Packaging and Shipment of Environmental Samples, for requirements for sample packaging and shipping.

14.3 PACKAGING AND SHIPMENT OF ENVIRONMENTAL SAMPLES

14.3.1 Purpose

The purpose of this procedure is to provide guidelines for the packaging and shipment of environmental samples from the survey site to ORNL via air freight or air express.

14.3.2 Applicability

This procedure applies to the packaging and shipment of environmental samples collected by ORNL-RASA personnel from survey sites.

14.3.3 References

1. ANSI N14.10.1, Administrative Guide for Packaging and Transporting Radioactive Materials, American National Standards Institute, September 14, 1973 (for guidance only).
2. ANSI N14.5, Leakage Tests on Packages for Shipment of Radioactive Materials, American National Standards Institute, December, 1974 (for guidance only).

3. ANSI N14.10.3, Administrative Guide for Verifying Compliance with Packaging Requirements for Shipment of Radioactive Materials, American National Standards Institute, March 19, 1975 (for guidance only).
4. Code of Federal Regulations, 10CFR71, Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions (for guidance only).

14.3.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

14.3.5 Responsibilities

14.3.5.1 Site Leader

The site leader is responsible for the implementation of this procedure. He will also determine the preferred shipper.

14.3.5.2 Survey Team Member

Any survey team member designated to package and ship environmental samples from the site to ORNL will follow the guidelines of this procedure.

14.3.6 Procedure

14.3.6.1 Packaging

1. Obtain the required number of commercial 5-gal steel cans with crimped lids (or equivalent shipping container).
2. Pack the collected soil samples and water samples into each can until full. Water and soil samples may be intermixed within one can.
3. Fill partially full cans with any type of packing material. Full cans need not be packed with packing materials.
4. Check each container with a gamma scintillation detector. If the external gamma radiation level observed at the surface of the container exceeds 20,000 cpm, notify the site leader. Repacking of samples may have to be conducted to minimize the external exposure.
5. Prepare packing list in duplicate, listing the samples within each can. Leave a copy of the packing list inside the can containing the samples listed.
6. Provide the site leader with a duplicate packing list that will be used to check the samples received when he returns to ORNL.

14.3.6.2 Can Labeling

Each can of samples is addressed to the ORNL-RASA program manager as follows:

PACKAGE NO. 1 OF "TOTAL NUMBER"

Mr. (Name of ORNL-RASA program manager)
Oak Ridge National Laboratory
Health and Safety Research Division
P. O. Box X, Building 7503
Oak Ridge, Tennessee 37831

14.3.6.3 Shipping

1. Obtain the name and address of the preferred carrier from the site leader.
2. Transport the shipping cans to the carrier and fill out the necessary shipping documents provided by the carrier.
3. Ship container collect with delivery at ORNL specified.

14.3.6.4 Regulatory Requirements

Environmental samples from RASA sites have not exceeded and are not expected to exceed radiation limits to require application of DOT transportation requirements.

If and when such radiation limits are reached or exceeded, refer to the following references or their latest editions for applicable regulatory requirements:

1. ANSI N14.10.1, Administrative Guide for Packaging and Transporting Radioactive Materials, American National Standards Institute, September 14, 1973;
2. ANSI N14.5, Leakage Tests on Packages for Shipment of Radioactive Materials, American National Standards Institute, December 1974;
3. ANSI N14.10.3, Administrative Guide for Verifying Compliance with Packaging Requirements for Shipment of Radioactive Materials, American National Standards Institute, March 19, 1975; and
4. Code of Federal Regulations, 10CFR71, Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions.

14.4 SAMPLE IDENTIFICATION AND LABELING

14.4.1 Purpose

The purpose of this procedure is to establish the guidelines for identification and labeling of samples obtained from survey sites.

14.4.2 Applicability

The procedure applies to the identification and labeling of soil, sediment, and water samples taken from survey sites by ORNL-RASA personnel.

14.4.3 References

None.

14.4.4 Definitions and Abbreviations

SAMPLE IDENTIFICATION ALPHANUMERIC (SIA). A unique sequence of letters and numbers assigned to the sample when it is collected.

Also see Sect. 1.5 of this manual, Terminology.

14.4.5 Responsibility

14.4.5.1 Site Leader

The site leader is responsible for initiation and implementation of this procedure.

14.4.5.2 Records Technologist

The records technologist is responsible for establishing the initial SIA for the site survey and for maintaining the records of the samples returned from the field.

14.4.5.3 Instrument Technologist

The instrument technologist assigned to collect samples is responsible for applying the SIA to the samples according to this procedure.

14.4.6 Procedure

14.4.6.1 Sample Identification

Each sample will be assigned a unique alphanumeric identification having a maximum of six characters and no imbedded blanks, hyphens, or punctuation. The format for the SIA will be established for each site by the site leader before the field work starts. This format will be entered in the Site Field Log Book. There are four basic parts to all SIAs as described in the following subsections.

SUBJECT: SAMPLE COLLECTION

Site designator alpha

The site designator will be comprised of one or two alpha characters that are established by the records technologist. For public or government properties, an attempt will be made to match the site designator to the initials of the site name. For private properties, for privacy reasons, the records technologist will designate a one- or two-letter code as the site designator. Because both one and two characters are permitted, the second alpha characters of a two-alpha site designator will not be B, C, D, S, or W because these characters are reserved for the designation of sample type.

Sample type designator alpha

The sample type designator will be established by the site leader and limited to a maximum of two alpha characters. The sample type designators describe the type of sample. Abbreviations commonly used are

W	Water Sample
WS	Water Sediment Sample
D	Drill Hole (or Core) Soil Sample
C	Composite Soil Sample
S or None	Systematic Surface Soil Sample
B	Biased Soil Sample

If any additional or different sample type designators are selected and the site designator is only one alpha character, care must be taken to avoid an alpha combination that would duplicate a previously used two-alpha site designator.

Numeric sequence number

The third part of the unique SIA should be a number. Because it may not be the first visit to the site, the records technologist will establish the beginning numbers for each sample type to be used on the new survey. The samples gathered on the site will begin with these assigned numbers and be followed in sequential order for the remaining samples.

Depth in drill hole (core) sample

When a drill hole sample is made, environmental samples are generally taken from the core from different depths. Because the sample type designator for drill core, D, is one character, at least one space is always remaining in the SIA. This space can be used for identifying sample depth. A single alpha character, A, B, C, etc. is appended following the numeric sequence number to differentiate between the depths of the samples. The actual depth of the sample is recorded in the Site Field Log Book.

Examples

1. CPW5 - Canonsburg Park Water Sample Number 5

CP W 5

Canonsburg Park ↑

Water Sample ↑

5th Water Sample ↑

2. XD15C - Salt Lake City Properties Drill Hole Number 15 from "C" depth

X D 15 C

Salt Lake City Properties ↑
(For this site, the letter "X" is arbitrarily assigned site designator alpha, in no way related to the initials of the site.

Drill Hole Soil Sample ↑

15th Drill Hole ↑

Sample Taken From Depth "C" ↑
(This sample taken from the third depth. For the actual depth, the field log will have to be consulted.)

3. For the CP site the drill hole depth designation was established as follows:

A = 0-6 in. Depth
B = 6-12 in. Depth
C = 12-30 in. Depth

These are examples of what was done for one site. For other sites, the site leader may establish different depths and enter the information in the Field Data Log Book.

14.4.6.2 Logging of Sample Identification and Information

Each day the site leader assigns to each instrument technologist the specific details on the samples to be collected. This will include type of sample, method of collecting, location, and range of sequence numbers to be given to samples collected. As the instrument technologist gathers the

samples, the SIA is written on the sample container ID tag in waterproof ink. Also written on the tag are the collection date, instrument technologist's initials, and any other information required to further define the sample condition and sample location (i.e., grid location where sample was taken). When the samples are returned to the site leader, the complete SIA is entered in the Site Field Log Book as well as all of the other pertinent information.

14.4.6.3 Sample Accountability During Handling and Shipping

Daily checks

At the end of each daily collecting period, the site leader compares the samples collected that day with the Site Field Log Book entries for that day to ensure a complete one-to-one correspondence.

Sample shipping

An invoice is prepared for each shipment package. The samples are checked off the log as they are packed and also against the Site Field Log Book for each sample.

Receiving

At the ORNL-RASA Laboratory, the samples within each shipment container are compared with the invoice to ensure that all samples are accounted for. During all remaining activities (handling, analysis, and storage), the SIA is always retained with the sample. The other information on the container tag written by the instrument technologist at the time of collection is entered in the Sample Receiving Log at ORNL. This information is available from the Site Field Log Book.

14.4.6.4 Sample Labeling

For soil and sediment samples, use a 3- to 4-in. wide yellow electrical plastic tape or equivalent to wrap around the plastic bags containing the samples and write the sample identification number on the tape with a waterproof ink pen. For water samples, write the sample identification number directly on a tape label on the polyethylene bottle, using a waterproof ink pen.

14.5 STORAGE OF ENVIRONMENTAL SAMPLES

14.5.1 Purpose

The purpose of this procedure is to describe the methods by which environmental samples are stored.

14.5.2 Applicability

This procedure applies to the storage of environmental samples collected from RASA sites and analyzed by ORNL-RASA personnel. Currently, only soil and sediment samples are stored.

14.5.3 References

None.

14.5.4 Definitions and Abbreviations

14.5.4.1 Definitions

BATCH. A batch of samples consists of all bottled aliquots derived from one raw sample.

Also see Sect.1.5 of this manual, Terminology.

14.5.4.2 Abbreviations

See Section 1.5 of this manual, Terminology.

14.5.5 Responsibilities

14.5.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for the implementation of this procedure.

14.5.5.2 Site Leader

The site leader is responsible for the proper collection, onsite documentation, and shipping of samples from sites under his jurisdiction. Onsite records are kept in the Field Data Log Book, including the identification numbers of the field samples, their sampling locations, and any special considerations. Once the samples are received at ORNL, responsibility for the sample processing, analyses, data recording, and storage is delegated to the laboratory and records technologists.

14.5.5.3 Records Technologist

The records technologist is responsible for keeping and maintaining records for sample storage.

14.5.5.4 Laboratory Technologist

The laboratory technologist will prepare and submit the soil and sediment samples to the records technologist for storage.

14.5.6 Procedure

NOTE: Only soil and sediment samples are currently stored for possible future retrieval. Water samples sent to the Analytical Chemistry Division of ORNL are evaporated in the process of analysis and, therefore, cannot be returned. Other environmental samples are not presently being obtained for analysis.

1. After counting each batch of soil or sediment samples, or after receipt of soil samples analyzed for uranium content from the Analytical Chemistry Division, the records/laboratory technologist will collect each batch of samples in a plastic bag, seal, and apply the alphanumeric identification number on the plastic bag as when the sample was collected.
2. The records technologist will acquire a closeable storage drum and assign an identification number to the drum.
3. Place the samples into the drum and record in the Sample Data Log Book the drum number and the identification numbers of all samples placed in the drum.
4. Provide a duplicate of the records to the site leader.
5. The storage drums are stored in a shed behind ORNL Building 7505. The storage will be indefinite until the ORNL-RASA program manager orders sample retrieval or until DOE issues instructions to discard the samples.

15. LABORATORY ANALYSES

15. LABORATORY ANALYSES

15.1 DETERMINATION OF RADIONUCLIDES IN SOIL AND SEDIMENT SAMPLES

15.1.1 Purpose

The purpose of this procedure is to establish the methods to be used to measure radionuclide concentrations in sediment and soil samples by using the Ge(Li) and high-purity Ge detector systems.

15.1.2 Applicability

This procedure applies to the analysis of sediment and soil samples by the Ge(Li) detector system and the high-purity Ge detector systems.

15.1.3 References

Sect. 14.9, Storage of Environmental Samples

15.1.4 Definitions and Abbreviations

15.1.4.1 Definitions

See Sect. 1.5 of this manual, Terminology.

15.1.4.2 Abbreviations

ND Nuclear Data Model 2400 Gamma Spectrometer.

5/11 Tennecomp TP 5/11 Gamma Spectrometer.

Ge(Li) Lithium-drifted germanium crystal semiconductor detection system.

HP-Ge High-purity germanium semiconductor detection system.

Also see Sect. 1.5 of this manual, Terminology.

15.1.5 Responsibilities

15.1.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for the implementation of this procedure.

15.1.5.2 Laboratory Technologist

The laboratory technologist will analyze sediment and soil samples according to this procedure.

15.1.6 Procedure

15.1.6.1 Equipment and Apparatus

5/11 system

1. Tennelec Corporation TP (Tennecomp) 5/11 Gamma Spectrometer,
2. Decwriter III Computer Terminal,
3. Ge(Li) crystal semiconductor detector in lead pig with hydraulic lid lifting unit, and
4. high-purity Ge crystal semiconductor detector in lead pig with hydraulic lid lifting unit.

ND system

1. Nuclear Data Corporation ND 2400 Gamma Spectrometer,
2. Pertec Magnetic Tape Data Storage Unit,
3. Pertec Paper Tape Perforator Unit, and
4. Ge(Li) crystal semiconductor detector in lead pig and hydraulic lid lifting unit.

General soil counting equipment

1. log books for each of the three soil counting systems,
2. soil sample bottles (25 cm^3), and
3. three carousels for holding soil samples (12 soil sample bottles per carousel).

15.1.6.2 Equipment Setup

All counting equipment electronic connections should be set up prior to normal operation of the systems. Settings for the controls should also be made prior to operation, although the current setting requirements may be checked against the information listed in the instruments' log books.

15.1.6.3 Soil Counting Procedure Using 5/11 System

Sample loading

1. This procedure applies to both 5/11 and ND systems.
2. Raise the lead pig lid by pressing the motor button on hydraulic lift pump with the right hand while holding lid handle with the left hand as a safety precaution.
3. Swing the lid to left side and remove the carousel.
4. Remove old sample bottles (if any) and load new bottles, cap end up, into the 12 positions in the carousel.
5. If less than 12 bottles are to be used, mapping of carousel positions should be checked for a given detector and sample vials should be arranged so that the efficiency deviation is as near to zero as possible, as shown in Weighted Counting Mapping for Soil Sample Carousel in Detector #1 [Ge(Li)] (Exhibit 15.10) and Weighted Counting Mapping for Soil Sample Carousel in Detector #2 (HP-Ge) (Exhibit 15.11).
6. Place the carousel on the detector crystal, red side to front in pig.
7. Close the lid by swinging it over with the left hand and holding the handle. to lower it, press the hydraulic release valve lever with the right hand.
8. Write "5/11," date, pig number, and time (24-h clock) on each sample bag.

The sample counting procedure is detailed in Exhibit 15.1.

15.1.6.4 Soil Counting Procedure Using ND 2400 System

Sample loading

1. Sample loading procedure is identical to that for 5/11 detector steps 1 and 2 (Sect. 15.1.6.3). See Weighted Counting Mapping for Soil Sample Carousel in Detector #3 [Ge(Li)] (Exhibit 15.14).
2. Place the carousel in detector 3 [Ge(Li)] with the red to the front.
3. Normally, cold samples are set for a 40,000 s count that is performed overnight.
4. Record sample identification in three places.
   a. On the pad by the analyzer. This listing, showing the order samples are run, is used to ensure the proper sample order when the paper tape is read into the PDP-10 computer.
   b. On the end of the paper tape. Record with a white pencil: the sample I.D., weight (g), date, time, and number of bottles counted.
   c. On the sample bag. Record the date and time and "ND3" (use 24-h time).

Counting Procedure

1. Press the two erase buttons; erase the existing spectrum before beginning sample count as shown in Photograph of ND 2400 System (Exhibit 15.9).
2. Set the acquire time (s). Select the counting time based on the sample activity. No more than 100,000 counts can accumulate in any one channel because this is the maximum the program can handle. Normally, cold samples are set for 40,000 s and counted overnight.

Data recording

Paper tape output.

1. After count is finished, the punched paper tape should output automatically if the auto recycle switch is turned to "single." If the detector has not "timed out," the time can be reduced on the counter by turning timer switch back to a lower value. If the tape does not start automatically, press the "input/output" (I/O) button. Check tape to see if time was recorded. If not, change the mode switch from "window" to "time/pass" and press the I/O button again. After a short amount of tape has read out, press the "stop/display" button. Read the time off this tape and write it down on the data tape. Switch the output switch from "time/pass" back to "window" and proceed.
2. Keep the paper tape for input into the PDP-10.

Magnetic tape storage. Place the data on magnetic tape using the following procedure:

1. Put tape drive on-line by depressing ON-LINE button. Button will light, showing it is ready.
2. Switch mode from OFF to DATA. See Photograph of ND 2400 System, Exhibit 15.9.
3. Press STOP button once, then press START button to read tape. After reading (takes only a few seconds), press STOP button again.
4. Switch mode from DATA to OFF.
5. Take tape drive back to OFF-LINE by pressing ON-LINE button. Light will go off. This prevents data from erasure in case of power failure.
6. Mark on pad that sample data were recorded on magnetic tape.
7. The spectra recorded on magnetic and paper tapes will be analyzed as described in Sect. 6.4.4.

PDP-10 analysis

Log-in procedure. The log-in procedure is detailed in Exhibit 15.2.

PDP-10 will respond with period to signal if it is in monitor state.

Paper tape handling. Take paper tapes in box to computer dispatch office, 4500 N, Rm. 273. Fill out job for listing tape ID.

DATA.BAS and GASPE.BAS programs. Check directory to see if paper tapes have been read into the computer. To check directory at the monitor level, type DIR/F. If tapes have been read in, follow the procedure detailed in Exhibit 15.3.

IBM 360/91 analysis (load module stored on PDP-10)

TAPE#.CDS Procedure. This procedure is detailed in Exhibit 15.4.

TRAN57.BAS program. This procedure is detailed in Exhibit 15.5.

MONSTR.BAS program. MONSTR.BAS is a BASIC Language interface to MONSTR.JCL, the Job Control Language used by the IBM 360/91. MONSTR.BAS writes a file named ANAL.CDS that is read by MONSTR.JCL when the job is submitted. This program should only be run after the magnetic tape and printout from the IBM 360/91 is returned. To ensure that TRANS7.JCL ran properly, the printout is checked to see if the filenames were written in. Another check is to type DIR/F on the PDP-10 to see if PTP?.PCH has been added to the directory. DIR refers to the directory of files for ORNL-RASA that is on disk 6642/11. The ? is the first letter of the two letter tape identification. See Exhibit 15.6 for detailed instructions.

Power failure recovery. See Power Failure Recovery for Gamma Spectrometers (Exhibit 15.7) for special procedure required for resetting ND 2400 and TP 5/11 after a power failure.

Monthly clock reset. See Monthly Clock Reset (Exhibit 15.8) for the routine procedure of monthly clock reset.

15.1.6.5 Documentation

The results (computer printouts) of the sample analyses are given to the records technologist who will record the data in the Soil Sample Data Log Book. The information to be recorded includes

1. Sample identification number
2. Sampling location/remarks
3. Sample weight (g)
4. Number of bottles per sample
5. The detector used for analysis
6. Computer data tagword
7. Storage location (ORNL archive)
8. Analytical results for the following radionuclides (all results given as $\pm 2\ \sigma$)

^{230}Th	^{223}Ra
^{226}Ra	^{137}Cs
^{232}Th	^{40}K
^{234}Th	^{211}Pb
^{239}U	^{231}Pa
^{228}Ac	^{235}U

When the value for a specific radionuclide is below the detection limit, ND is entered in the appropriate space.

15.1.6.6 Sample Storage

When the soil or sediment sample analyses are completed, the samples are sent to the records technologist for storage. See Sect. 14.9, Storage of Environmental Samples, for details.

15.2 URANIUM CONCENTRATION IN SOIL BY NEUTRON ACTIVATION ANALYSIS

15.2.1 Purpose

The purpose of this procedure is to describe the method for analyzing soil samples for uranium using neutron activation analysis.

15.2.2 Applicability

This procedure applies to the analysis of soil samples collected by the ORNL-RASA program personnel from radiological survey sites.

15.2.3 References

1. Sect. 14.9, Storage of Environmental Samples
2. Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples
3. Sect. 15.8, Soil and Sediment Sample Preparation

15.2.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

15.2.5 Responsibilities

15.2.5.1 ORNL-RASA Manager

The ORNL-RASA manager is responsible for the implementation of this procedure.

15.2.5.2 Site Leader

The site leader or his designee will prepare and forward the soil samples for analysis in accordance with this procedure.

15.2.6 Procedure

15.2.6.1 Background Information

The background information provided in this section serves only as a summary of the analysis and is not intended to be a detailed description of the analysis.

Neutron activation of soil samples for uranium concentration determination is performed by the Analytical Chemistry Division of ORNL. As the soil samples are prepared following Sect. 15.8, Soil and Sediment Sample Preparation, an aliquot of approximately 5 cm^3 is obtained for this analysis. The samples are irradiated at the Oak Ridge Research Reactor by subjecting them to a flux of about 6×10^{13} thermal neutrons per square centimeter per second. The concentration of ^{235}U in the soil is determined by counting the delayed neutrons emitted from the fission products produced by fissioning ^{235}U in the sample. Delayed neutrons are counted using a paraffin moderator with a BF_3 tube detector assembly. The ^{235}U content of the sample is obtained by comparing its delayed-neutron count to that obtained with a comparator sample containing a known quantity of ^{235}U. The ^{238}U is then calculated assuming that ^{235}U is 0.72% of natural uranium.

15.2.6.2 Detailed Procedure

1. Obtain a 5-cm^3 aliquot of the soil during sample preparation following Procedure 15.8, Soil and Sediment Sample Preparation.
2. Complete the Request for Control Analysis Form (Exhibit 15.15), attach to each sample, and send the samples to the Analytical Chemistry Division of ORNL.
3. On receipt of the results from the Analytical Chemistry Division, verify the sample identifications and enter the results in the Soil Sample Data Log Book. See Sect. 15.1.6.5.
4. Store the soil samples as described in Sect. 14.9, Storage of Environmental Samples.

15.3 DETERMINATION OF RADIONUCLIDES IN WATER SAMPLES

15.3.1 Purpose

The purpose of this procedure is to describe the method by which water samples are prepared and shipped for analysis.

15.3.2 Applicability

This procedure applies to the ORNL-RASA preparation of water samples obtained from RASA sites and the subsequent shipment of these samples for analysis.

15.3.3 References

1. Sect. 14.6, Packaging and Shipment of Environmental Samples
2. Sect. 15.2, Uranium Concentration in Soil by Neutron Activation Analysis
3. EPA-600/4-76-049, Sept. 1976, "Handbook for Sampling and Sample Preservation of Water and Waste Water" (for general guidance only)
4. ASTM Part 31, Water Method D 3370-76 (for general guidance only)

15.3.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

15.3.5 Responsibilities

15.3.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for the implementation of this procedure.

15.3.5.2 Site Leader

The site leader or his designee is responsible for the preparation of water samples for analysis in accordance with this procedure.

15.3.5.3 Laboratory Technologist

The laboratory technologist will prepare the water samples according to this procedure.

15.3.6 Procedure

NOTE: Water samples from survey sites are sent to the Analytical Chemistry Division of ORNL for analysis. Sample preparation at the site may include filtration and acidification. A brief description of this onsite processing is provided in this procedure for reference.

15.3.6.1 Apparatus

1. vacuum pump
2. glass funnel
3. rubber stopper with hole to fit funnel
4. vacuum flask
5. filter paper, Watman #42
6. HNO^3, concentrated
7. ring stand
8. sample container, 1 L

15.3.6.2 Filtration

1. Place the glass funnel with rubber stopper and filter paper on the ring stand.
2. Adjust the height of the ring so that the rubber stopper is tightly placed on the vacuum flask.
3. Connect vacuum hose to the flask.
4. Pour the water sample into the funnel and turn on the vacuum.
5. When filtration is complete, turn off the vacuum and transfer the filtered sample to a shipping container.
6. Transfer the sample identification number from the old container to the new one.

15.3.6.3 Acidification

To the sample in step (6) in Sect. 15.3.6.2, add 10 mL of concentrated HNO^3 and mix. Close the container cap tightly and store for later shipment to ORNL.

15.3.6.4 Sample Shipment

Refer to Sect. 14.6, Packaging and Shipment of Environmental Samples, for requirements for packaging and shipping the water samples to ORNL for analysis. Complete the Request for Control Analysis Form (Exhibit 15.15, Sect. 15.2, Uranium Concentration in Soil by Neutron Activation Analysis), for shipment of the samples to the Analytical Chemistry Division.

15.3.6.5 Documentation

Upon receipt of the analytical results from the Analytical Chemistry Division, verify the sample identification and enter the results in the Water Sample Data Log Book. The water samples are analyzed for ^{226}Ra, ^{230}Ra, and ^{210}Pb. These are reported in pCi/L.

NOTE: Water samples are returned by the Analytical Chemistry Division after analysis for temporary storage.

SUBJECT: LABORATORY ANALYSES

15.4 SOIL AND SEDIMENT SAMPLE PREPARATION

15.4.1 Purpose

The purpose of this procedure is to provide guidelines for the preparation of soil and sediment samples for analysis by ORNL-RASA personnel.

15.4.2 Applicability

This procedure applies to the preparation of soil and sediment samples collected by ORNL-RASA personnel from RASA sites.

15.4.3 References

1. Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples
2. Sect. 15.2, Uranium Concentration in Soil by Neutron Activation Analysis

15.4.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

15.4.5 Responsibilities

15.4.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for the implementation of this procedure.

15.4.5.2 Site Leader

In cases where sample processor services will be required at the site, the site leader is responsible for communicating the requirements of this procedure to the sample processor.

15.4.5.3 Laboratory Technologist

The laboratory technologist will prepare soil and sediment samples according to this procedure.

15.4.6 Procedure

15.4.6.1 Facilities, Equipment, and Supplies

1. Soil and sediment sample preparation facility
2. Sample vibrator table
3. Paper bags
4. Scale
5. Plastic sample vials with caps (weighed)
6. Marker pen
7. Sample preparation log book
8. Hand brush
9. Plastic bags
10. Aluminum drying trays
11. Safety glasses, masks, and gloves

SUBJECT: LABORATORY ANALYSES

Facility description

Soil and sediment samples are prepared in the ORNL-RASA Soil Preparation Facility. The facility consists of four ovens, a pulverizer, fan and ductwork, hood, compressed air, and a vacuum system with hose for cleanup.

The ovens (Exhibit 15.17) consist of three Single-Wall Transite Ovens (Blue M Electric Co.) and one Single-Wall Gravity Convection Laboratory Oven rated at 40 to 200°C. The ovens are mounted in parallel on a table with each oven connected to a vent header set at a negative pressure. A thermometer is set on each oven. The pulverizer is a BICO-BROWN PULVERIZER, Type UA, made by BICO Inc., Burbank, California, (Exhibit 15.18). It is set under a hood equipped with a vent fan, filter, and ductwork that exhaust to the outside of the building. Compressed air is available to the left of the hood and pulverizer equipment.

15.4.6.2 Sample Preparation

Sample drying

1. When samples are received, the laboratory technologist will enter the sample identification in Sample Preparation Log Book.
2. When ready to prepare the sample, remove it from the bags, place it in an aluminum pan and indicate sample identification on the pan. Place the pan inside an oven to dry. Turn on the oven switch. Save the paper bag and discard the plastic bag.
3. Dry the sample at 110°C for 24 h.
4. Turn off oven power after drying and let the sample cool before grinding it.

Sample grinding

1. Put on safety glasses and turn the duct fan on.
2. Clean the pulverizer, if necessary, with a brush and blow it with compressed air.
3. Adjust the grinding plates to provide ≤ 500 μm diam. sample particles.
4. Make sure the aluminum pan is in place to receive the crushed samples.
5. Turn the power on and feed a dried sample into the pulverizer.
6. After grinding, place the ground sample on the vibrator table (Exhibit 15.18) on which the plastic sample vials have been mounted. If uranium content is to be analyzed, one sample aliquot will be obtained at this stage for that purpose. (See Sect. 15.2, Uranium Concentration in Soil by Neutron Activation Analysis.)
7. Turn the vibrator power on until the vials are full of ground sample or until most of the sample is in the vials.
8. Wipe off excess sample from the vials and caps.
9. Blow excess dust from the surface with compressed air.
10. Weigh the capped sample vials.
11. Mark each vial with sample I.D.
12. Place the sample vials in paper bag and mark with sample I.D. and date.

Grinding facility cleaning

NOTE: After each sample grinding, the grinder has to be cleaned before grinding the next sample to prevent cross-contamination.

1. Turn the compressed air on and blow away the residual sample particles. (The duct fan will suck out the dust or sample particles.)
2. Loosen the grinder plates, dust with the brush, and use the compressed air again as in step (1) above.
3. Use vacuum to clean excess soil from the hood before proceeding with a new sample.
4. After cleaning the grinder, another sample can be ground. Follow the applicable steps in Sects. 6.2.2 and 6.2.3 of this procedure.
5. Turn off all power.

Documentation

1. For each sample to be prepared, enter the sample identification in the Sample Preparation Log Book.
2. Enter the weights of the sample vials after they are filled with samples.
3. Calculate the net weight of each sample in the vials.
4. Use an average tare weight for all vials.

Sample counting

The sample vials from step (12) of Sect. 6.2.2 of this procedure are counted following the procedure of Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples.

15.5 SAMPLE PREPARATION FOR SUBCONTRACTOR ANALYSIS

15.5.1 Purpose

The purpose of this procedure is to provide the guidelines for preparing samples for analysis by subcontractors.

15.5.2 Applicability

This procedure applies to ORNL-RASA preparation of samples for analysis by subcontractors. Preparation of soil, sediment, and water samples is covered in Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples, and Sect. 15.3, Determination of Radionuclides in Water Samples and is, therefore, excluded from this procedure.

15.5.3 References

1. Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples
2. Sect. 15.3, Determination of Radionuclides in Water Samples

15.5.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

15.5.5 Responsibilities

15.5.5.1 ORNL-RASA Manager

The ORNL-RASA manager is responsible for the implementation of this procedure.

15.5.5.2 Laboratory Technologist

The laboratory technologist is responsible for the preparation of samples for subcontractor analysis according to this procedure.

15.5.6 Procedure

(NOTE: The ORNL-RASA program does not currently engage the services of subcontractors for the analyses of environmental samples. The only samples obtained for offsite analyses are analyzed either by ORNL-RASA or by other divisions within ORNL. In rare instances, when soil and sediment samples need to be analyzed at the site, a local soil sample processor is subcontracted to provide the service. The processed samples are then analyzed by the ORNL-RASA staff at the site.)

Sample preparation for subcontractor analysis will depend on the capabilities of the subcontractor. A well-equipped subcontractor should require only onsite sample preparation such as filtration, acidification, preservative addition, etc.

Sample preparation requirements depend on the types of samples, analytical procedures to be used, radionuclides to be determined, instrument sensitivities, etc. Because different subcontractors may use different analytical procedures and instrumentation, it is mandatory that each subcontractor specify sample size, preparation requirements, detection limits, and analytical accuracy before contracts are awarded. Once a subcontractor is selected, sample preparation must follow his specifications.

Exhibit 15.1. Sample counting procedure.

Technologist action	CRT display	Function or comment
1. Insure floppy disks are in place in DSD drive of 5/11 system.		Decwriter III Computer Terminal interfaces with the 5/11 to acquire and analyze sample data
2. Push "Local-Line" key to place terminal in communication with 5/11 (line mode). Red light should be under the "on line" position. Push space bar	"COMMAND"	System is ready for use
3. Record Spectrum number sample ID, weight of sample (grams), and detector number in 5/11 Log Book		
4. Type AC and press space bar to transmit (See Exhibit 15.1-4)	"START ADC 1"	AC commands system to start acquiring data
5. Type YES and press space bar	"TIME"	Do step 5 if Detector 1 is used; If not, type NO; system continues
6. Type count time in seconds and press space bar	"START ADC 2"	
7. Type YES and press space bar	"TIME"	Same as step 5
8. Type count time in second and press space bar		ADCs are now accumulating data
9. Turn display scale to low setting to observe rate of acquisition	Display shows spectral data acquisition rate	Determines relative activity of sample. Normally, "cold" samples are set for a 40,000 second

Exhibit 15.1. (Continued).

Technologist action	CRT display	Function or comment
		count which is performed overnight. For other samples, the rule of thumb to assure adequate count times is that the observed spectrum be at half scale at minimum 7 (as set by the display scale). If full-scale spectrum is observed on display scale 10, sample is considered too "hot" to count
10. To stop count, set detector number on selector and press "ADC Stop" button		If sample is judged too "hot" for 5/11 use ND system. Otherwise, counting will stop automatically at end of set time
11. Press "Local-Line" key on terminal after counting is finished		Aids in preventing system crash in event of power failure
	<u>Data recording and analysis</u>	
1. Insure floppy disks are securely in place		5/11 Pulse Height Analyzer is used to store and analyze data
2. Press "Local-Line" key on terminal, and press space bar. (Red light appears under "on line")		5/11 is placed in communication with Decwriter III terminal

Exhibit 15.1. (Continued).

Technologist action	CRT display	Function or comment
3. Type SP and press space bar	"STORE, RECALL, PRINT OR MOVE?"	System is ready to process data
4. Type ST and press space bar	"SPECTRUM FILE No? (1-9999)"	System is ready to store spectrum data; stored as SPECXXXX
5. Type spectrum number and press space bar	"DISK NO?"	Spectrum number is recorded. Note that a maximum of 45 spectra should be stored on each disk. Storage attempt error is listed as a "27" error
6. Type disk no.	"REGION? (0, 1, 2)"	Disk number is number of floppy disks in use at time
7. Type detector number and region number that data is to be stored and press space bar	"SAMPLE ID"	Region 1 is used for Detector 1; region 2 is used for Detector 2
8. Type sample ID number (usually a 6-digit code) and press space bar	"SAMPLE WT. or VOL?"	Sample ID number is written on sample bag
9. Type sample weight (g) or volume and press space bar	"COMMAND"	Sample weight in grams (written on sample bag). Data storage will now be complete
10. Type SP and press space bar	"STORE, RECALL, PRINT OR MOVE?"	Same as step 3
11. Type RE and press space bar	"SPECTRUM NUMBER?"	System is ready to recall spectrum data
12. Type spectrum number and press space bar		Spectrum is now recalled and ready for analysis

SUBJECT: LABORATORY ANALYSES

Exhibit 15.1. (Continued).

Technologist action	CRT display	Function or comment
13. Type AN and press space bar	"DECAY TIME"	System prepared to analyze spectral data
14. Type 0 and press space bar	Terminal prints out data analysis	System will begin data analysis
15. Record counting time (live time) from printout in 5/11 record book		See sample of 5/11 Commands and Operation (Exhibit 15.1-4)
16. Remove completed analysis from printer after it stops		
17. Press "local line" key on terminal and press space bar		
18. Give printout to records technologist		

Exhibit 15.2. Log-in procedure.

Technologist action	CRT display	Function or comment
1. Turn Decwriter III (DECW 3) printer and tape reader to ON	Tape reader switch light comes on.	System readied for log-in procedure
2. Set switches on acoustic coupler to ON, FULL, and ACSI		Acoustic coupler is readied for tie-in with PDP-10
3. Dial 4-7474 and connect telephone receiver to coupler	Carrier light will come on	Terminal is tied in with computer
4. Press line/loc button up then press carriage return	Job number printer, PLEASE LOG IN OR ATTACH	
5. Type LOG 6642/11 and press carriage return	PASSWORD	Obtain password from manager
6. Type current password (six-letter maximum) and press carriage return	Daily messages from computing system are printed out	Password is not printed out by terminal
7. Type CTRLO (press CTRL and O at same time)		Daily message printing can be halted

Exhibit 15.3. DATA.BAS and GASPE.BAS programs.

Technologist action	CRT display	Function or comment
1. Type R#BASIC and press carriage return	READY, FOR HELP TYPE HELP	PDP-10 now in BASIC Language mode
2. Type OLD DATE and press carriage return	READY	Program DATE called up
3. Type 1 Correct day, month, and year and press carriage return		Example: 1 Wednesday, July 1, 1981, and press carriage return
4. Type REP and press carriage return	? FILE SAVED BUT NOT PROTECTED	Replaces old data with new
5. Type LISTNH	Printer types date entered	Check on date
6. Correct any data errors in files read from tape. Type OLD (FILENAME) and press carriage return	READY	
7. Type LISTNH line no. and press carriage return	Line will be printed out and READY	Line no. is line where correction is required
8. Retype entire line correctly and press carriage return		
9. Type REP and press carriage return		Line will be replaced with corrected line
10. Check line corrections by repeating Step 7		
11. Type OLD GASPE and press carriage return	READY	
12. Type 1 DATA FILENAME WEIGHT, FILENAME WEIGHT, etc.		Include filename weight pairs as were read off the tape into the PDP-10.

Exhibit 15.3. (Continued).

Technologist action	CRT display	Function or comment
13. Type RUNH and press carriage return		GASPE.BAS will begin to execute. See example of DATA.BAS and GASPE.BAS Program Input
14. Type in centroid ratios as requested according to table	Centroid Ratio 295.22 0.42 351.99 0.83	609.40 1.00 1120.40 0.35 1764.70 0.40 2204.50 0.13 For centroids not listed on table, type in ratio of zero. GASPE.BAS Program Input - Gamma Peak Centroid Ratios After the last centroid is found and its ratio typed in, the PDP-10 will print out the analysis results.
15. Printout of results must be detached from the DECW 3 and be kept as a permanent record		PDP-10 will continue to run until all files listed have been analyzed
	TIME #.## SECS and READY	System has returned to BASIC Language mode
16. Type SYS	EXIT	System leaves BASIC module and returns to monitor level

Exhibit 15.4. TAPE#.CDS procedure.

Technologist action	CRT display	Function or comment
1. Type RPIP and press carriage return	*	Ready to enter magnetic tape data identification
2. Type TAPENAME 2 letters max CDS=TAPE#, CDS, FILENAME, CDS FILENAME. CDS, etc. and press carriage return	*	Include as many file names as are on the tape, in same sequence as they were recorded by the ND
3. Type CTRLC, CTRLC		Returns system to monitor level from PIP
4. Type DA and press carriage return	Date and Time	
5. Type TYPE TAPENAME.CDS and press carriage return	Types out TAPE#.CDS FILE	Files on file tape are printed out to check
6. Type DEL FILENAME.CDS, FILENAME.CDS, etc. (or type first three digits of file names to be deleted followed by ???.*) and press carriage return	FILES DELETED and list of these files.	Statement deletes file names opened when tape is read into computer (shorthand method of deleting files is in parenthesis)
7. Type K/N and press carriage return	Job, No., number of files saved on disk, and run time in seconds	Log off procedure for PDP-10
8. Turn DECW 3 printer switch, acoustic coupler switch, and tape reader switch to off; replace telephone receiver		Completed log-off procedure

Exhibit 15.5. The TRAN57.BAS program.

Technologist action	CRT display	Function or comment
1. Follow log-in procedure		
2. Type R#PIP and press carriage return.	*	System is ready for input
3. Type TAPENAME. BAS/0=TAPENAME CDS and press carriage return		TAPENAME.CDS is renamed TAPENAME.BAS so it can be used by BASIC system. Line numbers are added
4. Type CTRLC, CTRLC and press carriage return		System returns from PIP to monitor level
5. Type RBASIC and press carriage return	READY, FOR HELP TYPE HELP	System is in BASIC Language mode
6. Type OLD TRANS7 and press carriage return	READY	System accessed to TRANS7 program
7. Type 1 DATA TAPENAME, N and press carriage return		TAPENAME is name of magnetic tape and N is number of files on tape (30 maximum
8. Type RUNH and press carriage return	Program prints out instructions and ENTER BEGINNING TAGWORD?	
9. Type TAGWORD and press carriage return		Tagword identifies each file, list is usually kept above the DECW 3
10. After output is finished type SYS and press carriage return		System returns to monitor level
11. For corrections required in the file data, see "Introduction to TECo (Test Editor and Corrector) Manual." Make corrections according to procedure outlined in this manual at the monitor level		

Exhibit 15.5. (Continued).

Technologist action	CRT display	Function or comment
12. Type #SUBMIT and press carriage return		Command enters the job on the 360/91; load module is transferred)
13. Type TRANS7.JCL and press carriage return		PDP-10 returns to monitor level
14. Type RSTATUS and press carriage return	Job number is printed	Make note of job number for listing on job submittal card
15. Type K/N and press carriage return, and follow normal log-off procedures		
16. Hand carry magnetic tape with job submittal card to dispatcher's office		

Exhibit 15.6. MONSTR.BAS program.

Technologist action	CRT display	Function or comment
1. Type R#BASIC and press carriage return	READY, TYPE HELP FOR HELP	
2. Type OLD MONSTR and press carriage return	READY	
3. Type 1 DATA TAPENAME ,N and press carriage return		TAPENAME is the tape previously run through TRANS7 to store its data on mass storage. N is the number of files on the tape
4. Type RUNNH and press carriage return		PDP-10 will execute the MONSTR.BAS program
5. Program Function is printed out	FOR TABLE TYPE 'YES'	No table - go to step 6
6. Type carriage return	COMMAND#?	
7. Type 1 and press carriage return	SAMPLE IS 'FILE-NAME' WANT SAMPLE DECAY? TYPE YES	No sample decay - go to step 8
8. Press carriage return	DO SOMETHING WITH SPECTRUM? and COMMAND#?	
9. Type 11 and press carriage return		Repeat step 8 for each file on TAPENAME
10. When last spectrum is reached, program will print the message under CRT dislay column	DO SOMETHING WITH THIS LAST SPECTRUM ON TAPENAME and COMMAND?	
11. Type 12 and press carriage return	Set of instructions and TIME: #.## SECS and 'READY'	
12. Type SYS and press carriage return	*	

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Exhibit 15.6. (Continued).

Technologist action	CRT display	Function or comment
13. Type R SUBMIT	*	Transforms load module to IBM computer
14. Type @MONSTR.JCL and press carriage return	JOB QUEUED for IBM 360/91	System returns to monitor level
15. Type RSTATUS and press carriage return		PDP-10 will list job number. Note this for future reference
16. Type K/N and follow the normal log-off procedure		

Exhibit 15.7. Power Failure Recovery for Gamma Spectrometers.

ND 2400 System

A power failure while data is being accumulated (the usual case) should stop all ADCs, which would then have to be restarted manually. The mechanical analyzers (ND 100, ND 2400) require a precise order of recovery. The computer-based system (Tennecomp 5/11) recovery depends on the nature of the failure or whether or not the system has abnormally terminated. (See first page of Tennecomp 5/11 system section to determine if system has abnormally terminated).

1. When power is lost, the ND systems always turn off the analyzer, causing it to go into the STOP mode. The nine-track tape drive relaxes and must either be rewound and "counted back down" to the location at the time of the power failure or rewound and removed from the machine (this is usually done if there are more than 20 spectra already on tape).
2. If the data accumulation is not sufficient to get good data from the count, the sample must be recounted. Before restarting the analyzer, the calibration and stabilization must be checked (monitor gauge should be in the 40 to 60 range).
3. Normally, the monitor gauge on the stabilizer will register about 50 divisions while in operation. When loss of power occurs, this meter will deflect nearly full scale or nearly zero.

When power is restored, this meter will indicate a large deviation from 50% of scale and the stabilizer will shift the ADC as much as 100 channels either plus or minus. The gain switch on the left (gain) side of the analyzer must be switched from ON (center position) to RESET (up). This removes the voltage that has moved the gain enough to shift the ADC up or down the scale. This switch is left in RESET position while the ADC is checked for ZERO and STABILIZER POINT positions.

The gain on the linear amplifier should not have to be moved more than one division to recover the operating position. Normally, the sodium source (for stabilization) can be used to reset the stabilizer. The highest energy generated by this source is 2.7935 MeV and is set by binary switches turned to the left (ON) position.

Those switches necessary for setting the 2.7935 MeV peak are 2048, 512, 128, 64, 32, 8, and 2. These are the binary switches on the gain section (left side) of the stabilizer. To get a better picture of the sodium source, it may be necessary to remove the carousel and sample and place the source directly on top of the crystal. Once the gain has been adjusted so that the peak falls within one channel of its correct energy, the stabilizer switch can be moved from RESET to the ON position. To check any peak in the spectrum of the analyzer, set the binary switches on the right side of the analyzer, according to the energy desired, then push the small "calibrate" button at the bottom of the binary switches.

Exhibit 15.7. (Continued).

Tracer will appear in the position on the analyzer where the peak has been calibrated to occur. If the source peak does not coincide with the calibration, a gain or zero adjustment is necessary. The stabilizer should be able to hold the gain in a single channel while the zero is adjusted one or two divisions to bring the lower end (lower energy) of the spectrum into calibration.

Note that increasing the scale reading on the "zero" knob on the ND ADC moves the zero upscale (to higher energies). This is the exact reverse of the action on the Tracor Northern NS-623 ADCs on the Tennecomp 5/11 system.

All the DC type stabilizers work in a manner similar to the ND system just described. This will apply when stabilizers are added to the Tennecomp 5/11 system, which has Tracor Northern NS-612 ADCs.

The Tennecomp 5/11 System

When power failure has occurred, any spectrometer must be checked for the next several runs to determine whether the electronics have stabilized themselves. Usually the 5/11 system will recover with only about 1/2 keV shift if the system has been down for only a short while. In any event, the energy calibration has to be checked with some kinds of sources before new samples can be counted. Stabilizers must be RESET before attempting energy calibration checks.

1. After a power failure, if the keyboard on the teletype works and if the system responds to commands (such as SP, G, or AC), the operating system has probably recovered. However, if the keyboard will not work when the teletype is ON LINE, then the switchkey on the 5/11 should be switched from power to OFF and then back ON to power with the teletype still ON LINE. If, after doing this, the teletype prints, for instance, "21:10 POWER FAIL," then the system is probably functioning properly. The clock time will have to be reset, and most likely the library (LI), the full-width half max (FW), the calibration (CA), and the minimum detectable limit (MD) will have to be reloaded from disk.
2. If the teletype does not print anything and will not respond to typed commands, a reloading of the operating system is necessary. The HPLSQ disk must be removed from disk drive 0 (left side). A copy of the TSI-KUS-5A-01 program on a disk must be inserted in the 0 drive. NOTE: The label must be at the front and facing the left side of the machine (the disk label). There are three copies of this TSI disk.
3. Push the "Halt" switch on the computer. Check the paddle switches on the 5/11, and reading in binary (starting from the left side), make sure the switches are set for 1 7 3 0 0 0. For a paddle switch to be in the numerical position it must be in the up position. A paddle switch represents a zero if it is in the down position.

Exhibit 15.7. (Continued).

To read in OCTAL, read in color-coded groups starting from the key to the farthest right in that group.

Starting at the far left side of the paddle switches, you will see that only one paddle switch (No. 15) is in the first group.

Groups are indicated by color. The number 15 switch should be up, and because it is the only up switch in its group, it represents a 1. Moving to the right to the next group, which has three numbers, all three (Nos. 12, 13, and 14) should be up. In binary, the key to the farthest right represents a 1, the next key moving left represents a 2, and the left-side key in a group represents a 4. So if the 1, 2, and 4 switches are all up, then a 7 is represented (1 + 2 + 4 = 7).

In the next group, the Nos. 9 and 10 switches are up and the No. 11 switch is down indicating that the number represented is a 3 (1 + 2 + 0 = 3). In the next three groups (Nos. 6, 7, 8; 3, 4, 5; and 0, 1, 2) all switches are down, indicating three zeros.

From these procedures comes the required number 1 7 3 0 0 0.

If any red lights are lit on the disk drive panel to far left of disk drives, turning the floppy disk power switch OFF and back ON should clear them all.

4. Press the LOAD switch down momentarily. Flip the HALT switch back out of the halt position and press the RUN/START switch (it is a momentary switch and will not stay down).
5. Meanwhile, the terminal should be in the ON LINE mode and should respond with

   TSI-KUS-51-01
   and then a *.
   Next, enter a QTO and a carriage return.
   Machine response: *
   Then enter QI and a carriage return.
   Machine response: *FILE:
   Then enter the number 3103 and a carriage return.
   Machine response: *
   Then enter RO and a carriage return.
   Now the TPOS operating system is engaged.
6. Remove KUS disk and insert the HPLSQ disk back into the 0 disk drive. You should now have a display on the screen. Machine response: *

Exhibit 15.7. (Continued).

Type L T 17; L I HPLSQ; L C and a carriage return. (Note the spaces between the Ls and the T, I, and C). The number 17 is the "name" of disk drive 0 in the TPOS programming language.

7. HPLSQ1 will be the part of the program to come in first; it sets the clock and the number of channels, etc.
Machine response: ISOTYPE
Machine response: Enter DAY: HOUR: MIN:
For example: DAY: Type day of month, hour of day, minutes after hour, and hit space bar between entries.

Machine response: Enter origin and length of analysis region: Type a 1, hit the space bar and type 2688. A carriage return (or space) should always follow anything when you have finished typing a line or when you want to give the system a command.

Machine response: Primary commands the system will accept for retrieving or storing data from on into memory onto a disk are then listed. Next the disk system will pull HPLSQ back into memory. Wait until COMMAND: appears on the teletype printout--now you are ready to reload the library, etc., into the core.

NOTE: When storing data or recalling data from a disk, the 5/11 works much faster if the display is turned off. This is done by pushing the ON/MAIN TRACE button directly below the screen in and then pushing it out again.

If the system must be reloaded, the library, etc., must be reloaded into core manually from the disk.
Machine response: COMMAND:
Operator types: LI and a carriage return
Machine: RECALL, PRINT, or CHANGE:
Operator types: RE and a carriage return
Machine: LIBRARY NO:
Operator types: 226 (this is the carousel library, sometimes other libraries are used.)
Next you must load the MDA.
Machine response: COMMAND:
Operator types: MD and a carriage return
Machine: RECALL, PRINT, or CHANGE:
Operator types: RE and a carriage return
Machine: MDA FILE NUMBER:
Operator: 226 (for carousel only)
Next for loading is the FWHM.
Machine response: COMMAND:
Operator: FW

Exhibit 15.7. (Continued).

Machine: FWHM #:
Operator: 226 (for carousel only)
Machine: PRINT FWHM TABLE:
Operator: No
The calibration for the detector you wish to start up must be reloaded before you can analyze a spectrum from that detector.
To reload calibrations into memory core from the disk:
Machine response: COMMAND:
Operator: CA and a carriage return
Machine: RECALL or CALIBRATE
Operator: RE and a carriage return
Machine: CALIB # CB:
Operator: Type the calibration number 1 if you want to analyze from detector 1, type 2 if you want to analyze from detector 2, etc.
Machine: PRINT CALIB. TABLE;
Operator: Type NO and carriage return
Last, the EX command must be reloaded to adjust the search routine.
Machine response: COMMAND:
Operator: EX and a carriage return
Machine: Width parameter (4-8):
Operator: 4
Machine: Energy window for search (1-3):
Operator: 1
Machine: Residual Limit (3-5)
Operator: 3
Machine: Reject level-error % (10-100):
Operator: 10

The above settings are correct for all types of counting except well-type counting. Here the width parameter is 6, energy window for search is 1, and reject level is 20, though the residual limit is not changed. Since the gain is changed on each linear amp to count with the well detector (two divisions up on the coarse gain), only the well version of HPLSQ asks for approximate gain on calibration (normally 0.2 keV/channel).

Exhibit 15.8. Monthly Clock Reset.

At the first of each month, the clock must be reset to change the date and time. This is a standard operating procedure. To do this, line 5.29 in HPLSQ is changed on the disk in drive 0. First type 2 Control C's (by holding down the Control key and striking the C key). The machine should indicate that you are at the beginning (00 at 76) of HPLSQ. Next type a capital W, then a space, and then the number 5.29 (example: W 5.29 - writes out the line).

Then type M 5.29. The W stands for write and the M stands for modify. The 5/11 will print out line 5.29 as it now is written on the disk. To modify the line for a new month, type the last letter of the month that is now on the disk (e.g., if it is August and the month on the disk is still July, type a y), and the 5/11 will search until it finds that last letter of that word (month), and type in the correct month, then a line feed (not carriage return). Note that the deletes are from right to left and spaces are the same as characters. Now you are ready to store this new line on disk:

Type 2 Control C's
Type S QX = 1.4 (Provides a return address.)
Machine: *
Type L T 17
Machine: *
Disable write protect switch (below disk drive 0) by flipping the switch to the left.
Operator: Type D 90 (carriage returns always follow any command at the monitor level).
Machine: * (HPLSQ is no restored on disk).
Operator: Type S YE=0
Machine: *
Operator: Type G and a carriage return
Enable write protect

Refer to Exhibit 15.13, Sect. 7 for instructions on resetting the clock time. A copy of the TIL language program used to operate the 5/11 can be found in the disk under the ND 2400.

Exhibit 15.9. Photograph of ND 2400 system.

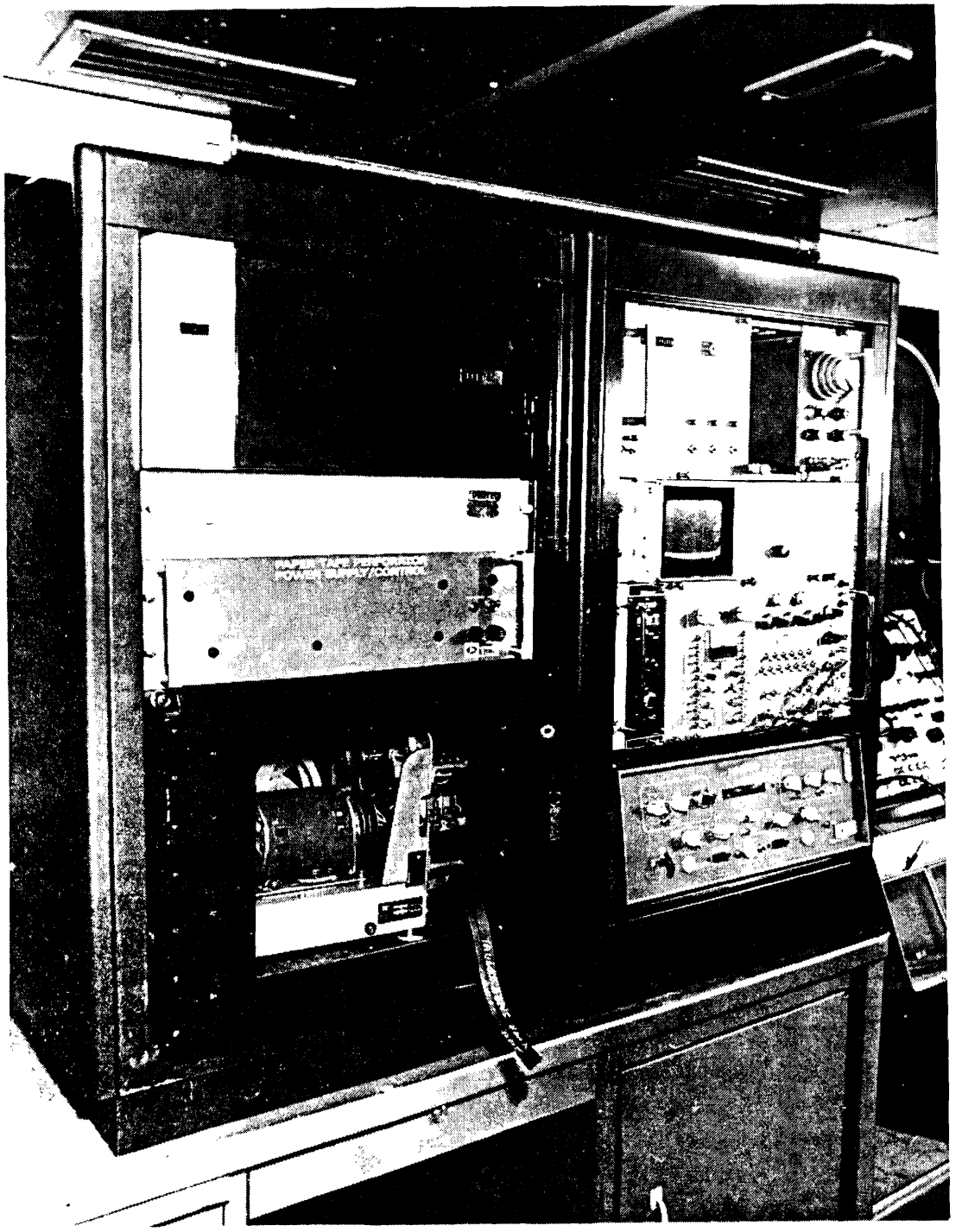


Exhibit 15.10. Weighted counting mapping for soil sample carousel in Detector #1 [Ge(Li)].

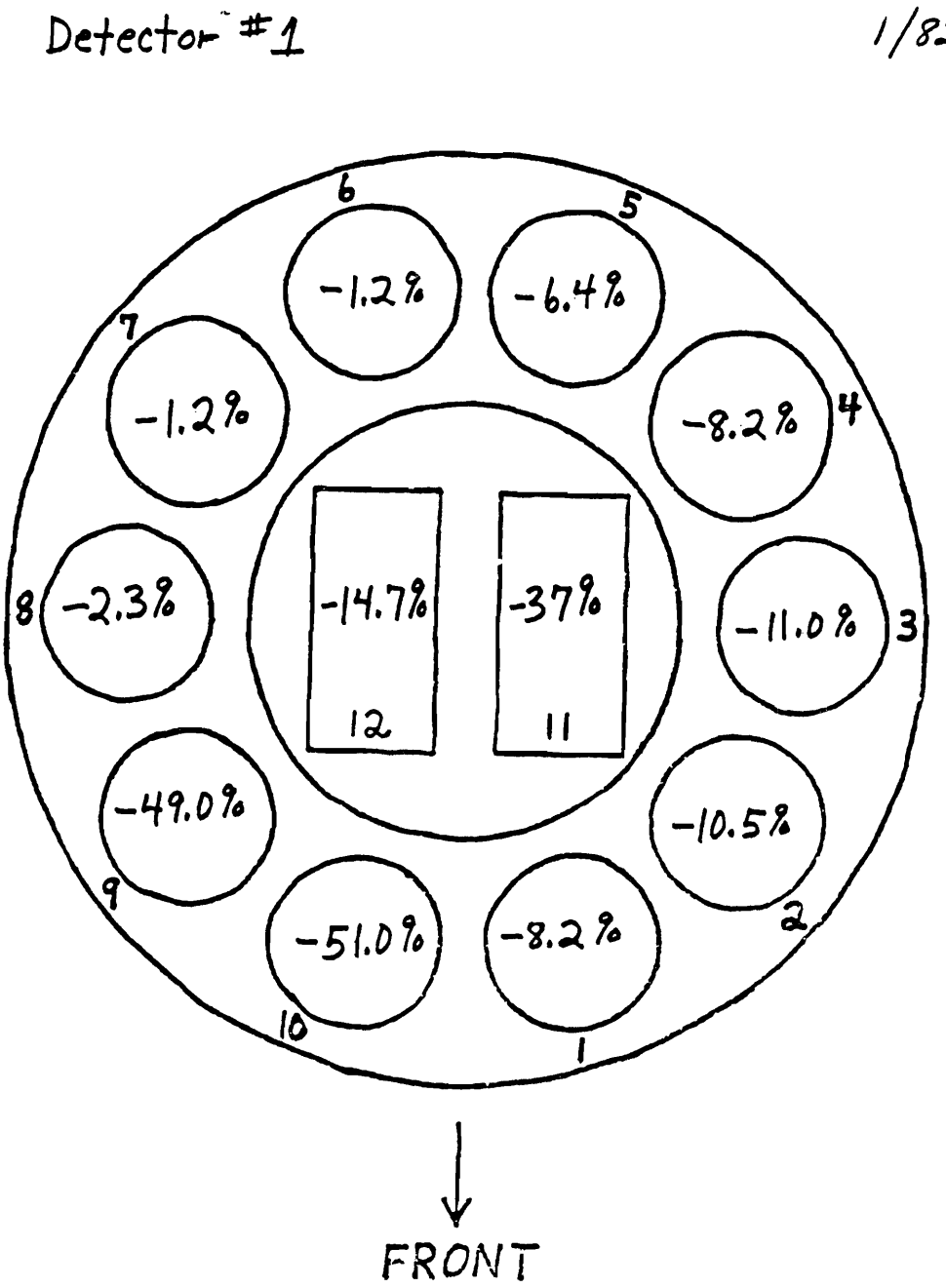


Exhibit 15.11. Weighted counting mapping for soil sample carousel in Detector #2 (HP-Ge).

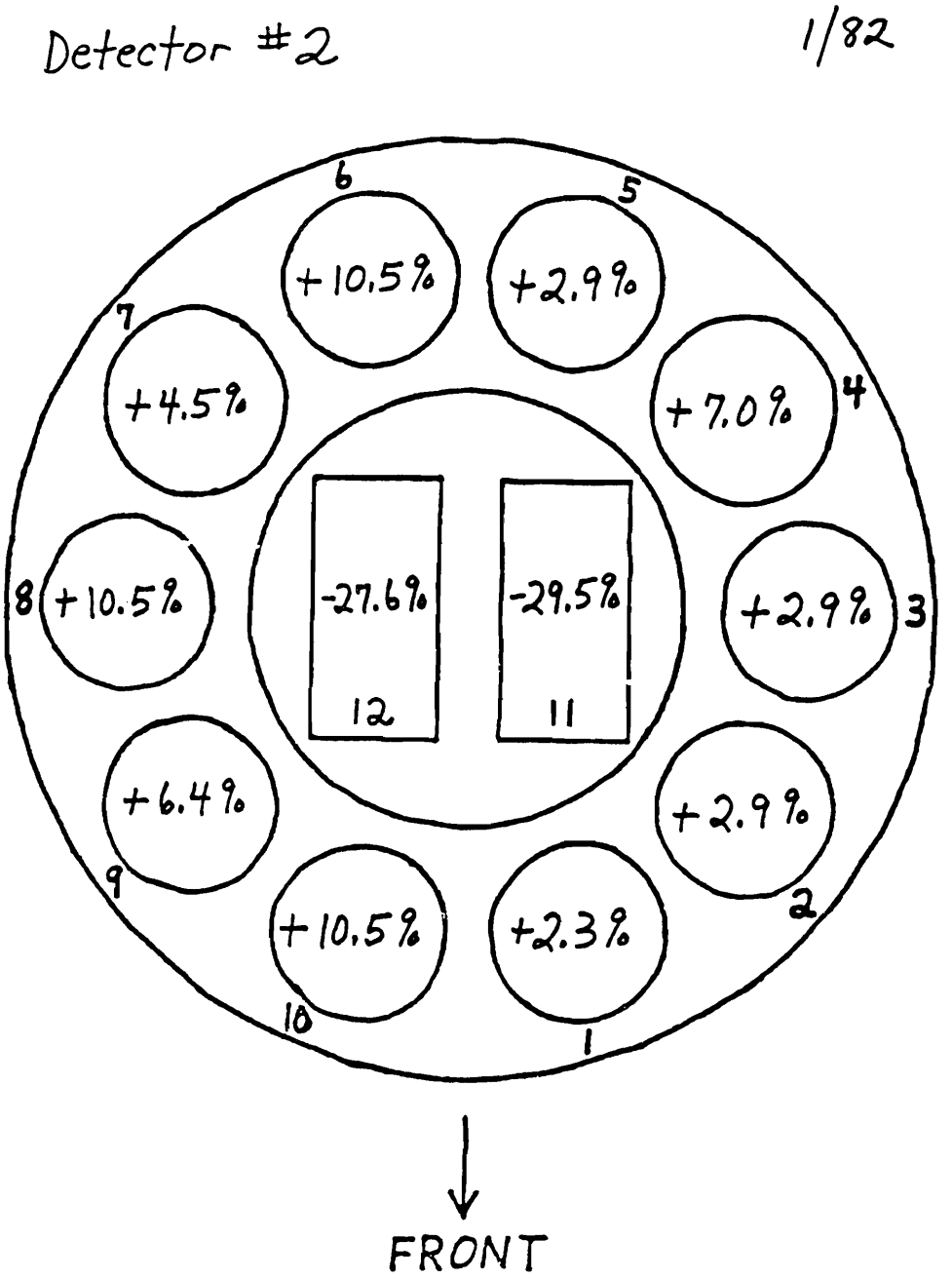


Exhibit 15.12. Photograph of Tennecomp TP 5/11 and DECW 3.

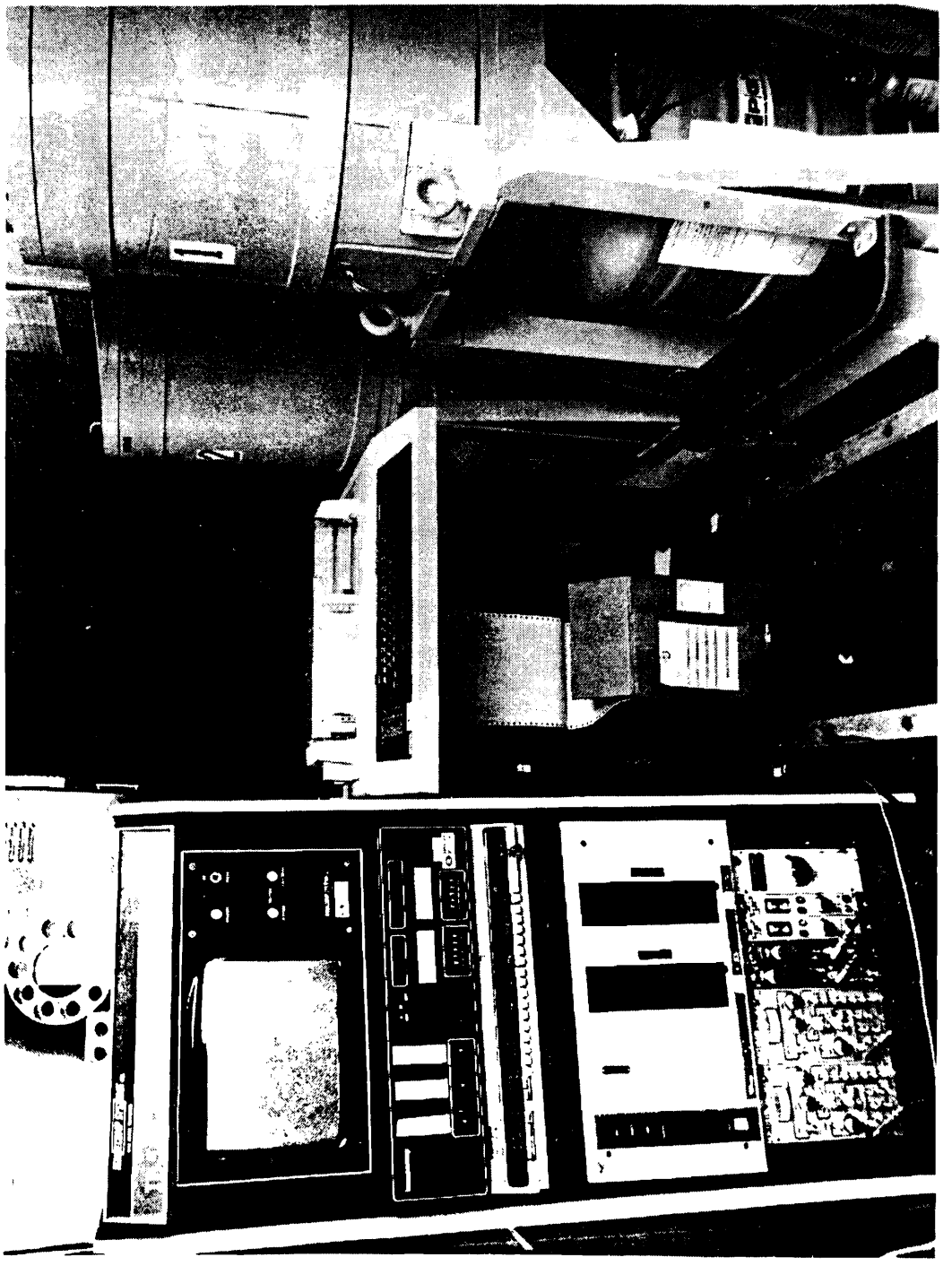


Exhibit 15.13. Sample of 5/11 commands and operations.

```
COMMAND:
TSI-KUS-5A-01
*

  QTO
* QI
FILE 3103
* RO
TPOS-2013

?OO AT 00.00
*L T 17;L I HPLSQ;L C


ISOTYPE

ENTER DAY, HOUR, MIN:   2   15   30


ENTER ORIGIN & LENGTH OF ANALYSIS REGION: 1   2688



PRIMARY COMMANDS ARE:
CALIBRATE, LIBRARY, SPECTRUM, FWHM, MDA, EXECUTE, ANALYZE,
ACQUIRE, FILES, QUIT

ONLY TWO LETTERS ARE SIGNIFICANT FOR ANY COMMAND


COMMAND:LI
RECALL, PRINT OR CHANGE? :RE
LIBRARY NO.? :226

COMMAND:MD
RECALL, PRINT OR CHANGE?:RE
MDA FILE NUMBER?   226

COMMAND:FW
RECALL OR CHANGE? :RE
FWHM # ? WH:226
PRINT FWHM TABLE?NO


COMMAND:CA
RECALL, OR CALIB? :RE
CALIB. # ? CB:1
PRINT CALIB. TABLE? NO

COMMAND:EX
WIDTH PARAMETER? (4-8) :4
ENERGY WINDOW FOR SEARCH? (1-3) :1
RESIDUAL LIMIT? (3-5) :3
REJECT LEVEL-ERROR %? (10-100) :10
```

SUBJECT: LABORATORY ANALYSIS

Exhibit 15.13. (Continued).

```
COMMAND:
?00 AT 76.50
*W 5.29
05.29 T "DAY =", %4,FDAY(0)," NOVEMBER ,1981   TIME =",%7.02,FTDAY(),!!

*M 5.29
T "DAY =",%4,FDAY(0)," NOVEMBER// ,1981   TIME =",%7.02,FTDAY(),!!
*W 5.29
05.29 T "DAY =",%4,FDAY(0)," NOVEMBER// ,1981   TIME =",%7.02,FTDAY(),
!!
*M 5.29
T "DAY =",%4,FDAY(0)," NOVEMBER//\\\\\\\\\DECEMBER  ,1981   TIME =",
%7.02,FTDAY(),!!
*W 5.29
05.29 T "DAY =",%4,FDAY(0)," DECEMBER  ,1981   TIME =",%7.02,FTDAY(),!
*S QX=1.4
*D 90
*S YE=0
*G


ISOTYPE

ENTER DAY,HOUR,MIN:   1   8   51


ENTER ORIGIN & LENGTH OF ANALYSIS REGION: 1   2688
```

Storing a spectrum on disk from core

```
          SP
STORE,RECALL,PRINT OR MOVE? :ST
SPECTRUM FILE NUMBER? (1-9999) SC:4352

DISK NO.?27

REGION? (0,1,2) 1
```

Recalling a spectrum from disk into core

```
SAMPLE ID.? X90
SAMPLE WT OR VOL? 332.9
COMMAND:SP
STORE,RECALL,PRINT OR MOVE? :RE
SPECTRUM NUMBER? SC:4352
```

Start ADC acquisition

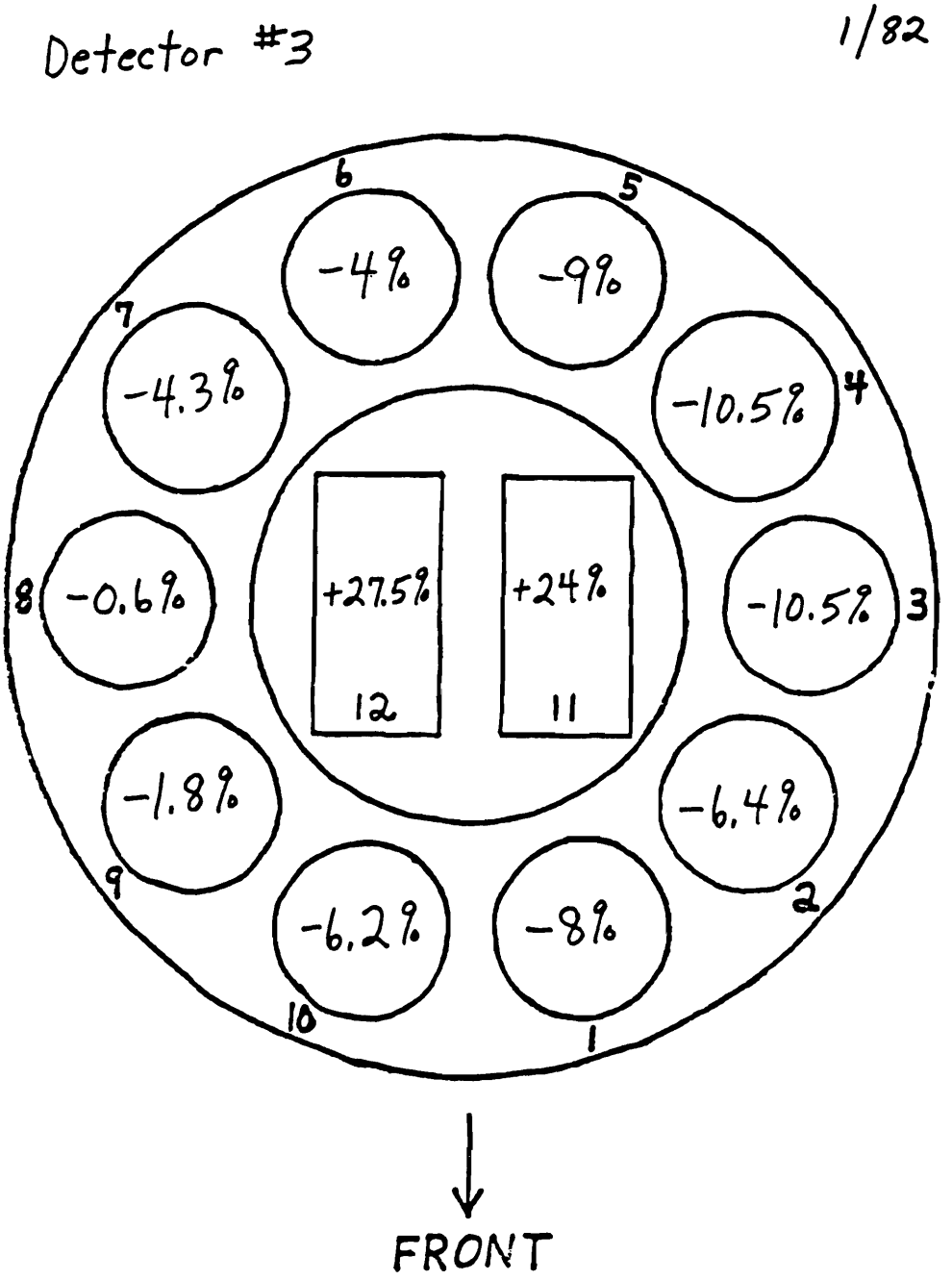
```
COMMAND:AC

START ADC NO. 1:YES    TIME? 40000
START ADC NO. 2:NO
```

Analyzing a spectrum that is in core

```
COMMAND:AN
DECAY TIME? :
```

Exhibit 15.14. Weighted Counting Mapping for soil sample carousel in Detector #3 [Ge(Li)].



SUBJECT: LABORATORY ANALYSIS

Exhibit 15.15. Request for control analysis form (UC-1910).

REQUEST FOR CONTROL ANALYSIS

THIS FORM IS TO BE USED ONLY FOR SAMPLES CONTAINING LESS THAN 50 MILLIGRAMS CONCENTRATION OF FISSIONABLE MATERIAL.

CONTROL NO.

DATA REPORT TO | BUILDING NO. | SERIES NO.

DATE SUBMITTED | TELEPHONE NO. | CHARGE NO.

SAMPLE CODE		DESIRED ANALYSIS	ESTIMATION OF CONCENTRATION	PREVIOUS HISTORY OF SAMPLE	NATURE AND ESTIMATION OF ACTIVITY	CONCENTRATION OF ALL CONSTITUENTS IN SAMPLE

REQUESTER

Sample(s) contain_____g of Fissile Mtrl. (est)

Return to sender or dispose according to H.P. Manual.

UCN-1910
(3 6-71)

Exhibit 15.16. Bank of drying ovens.

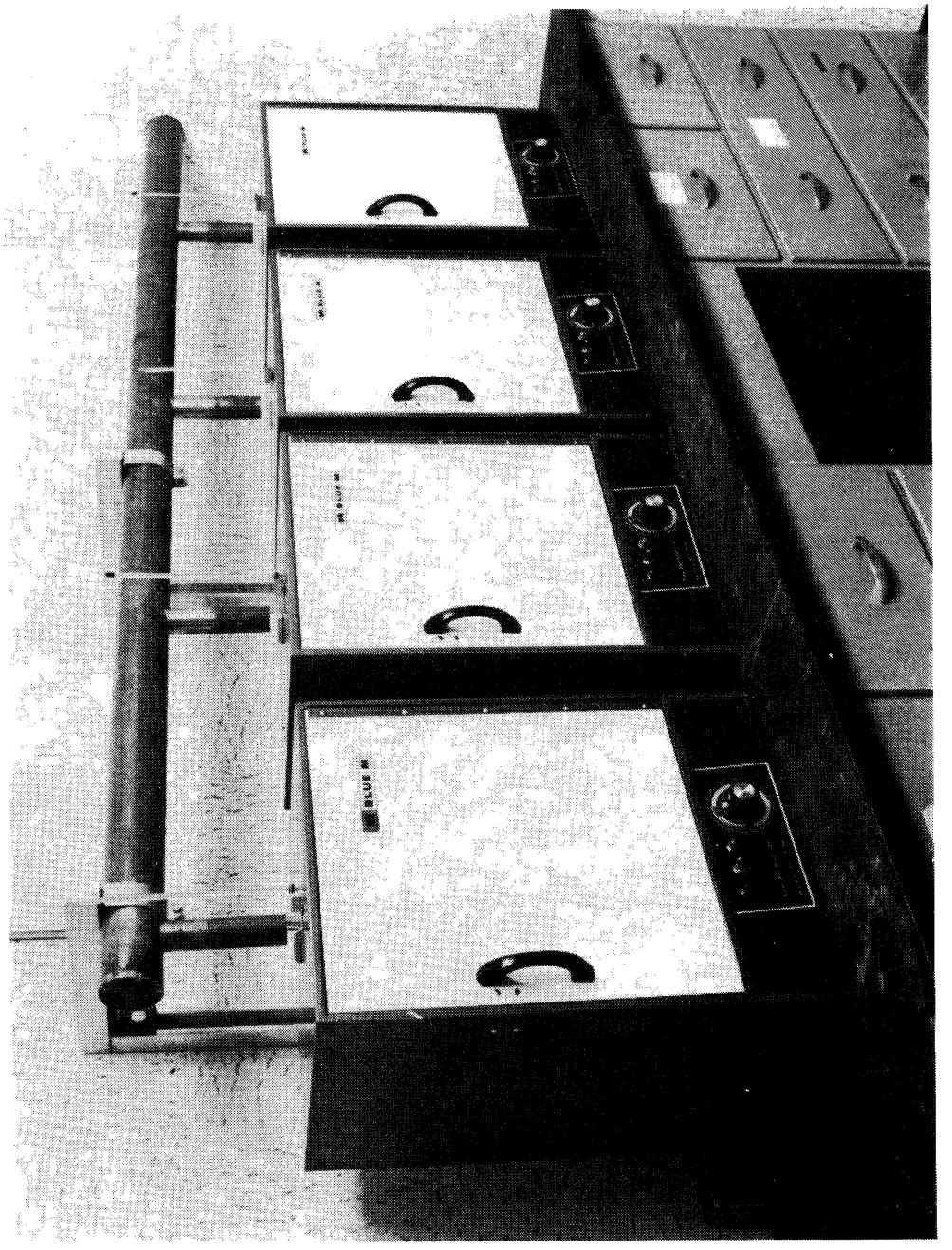
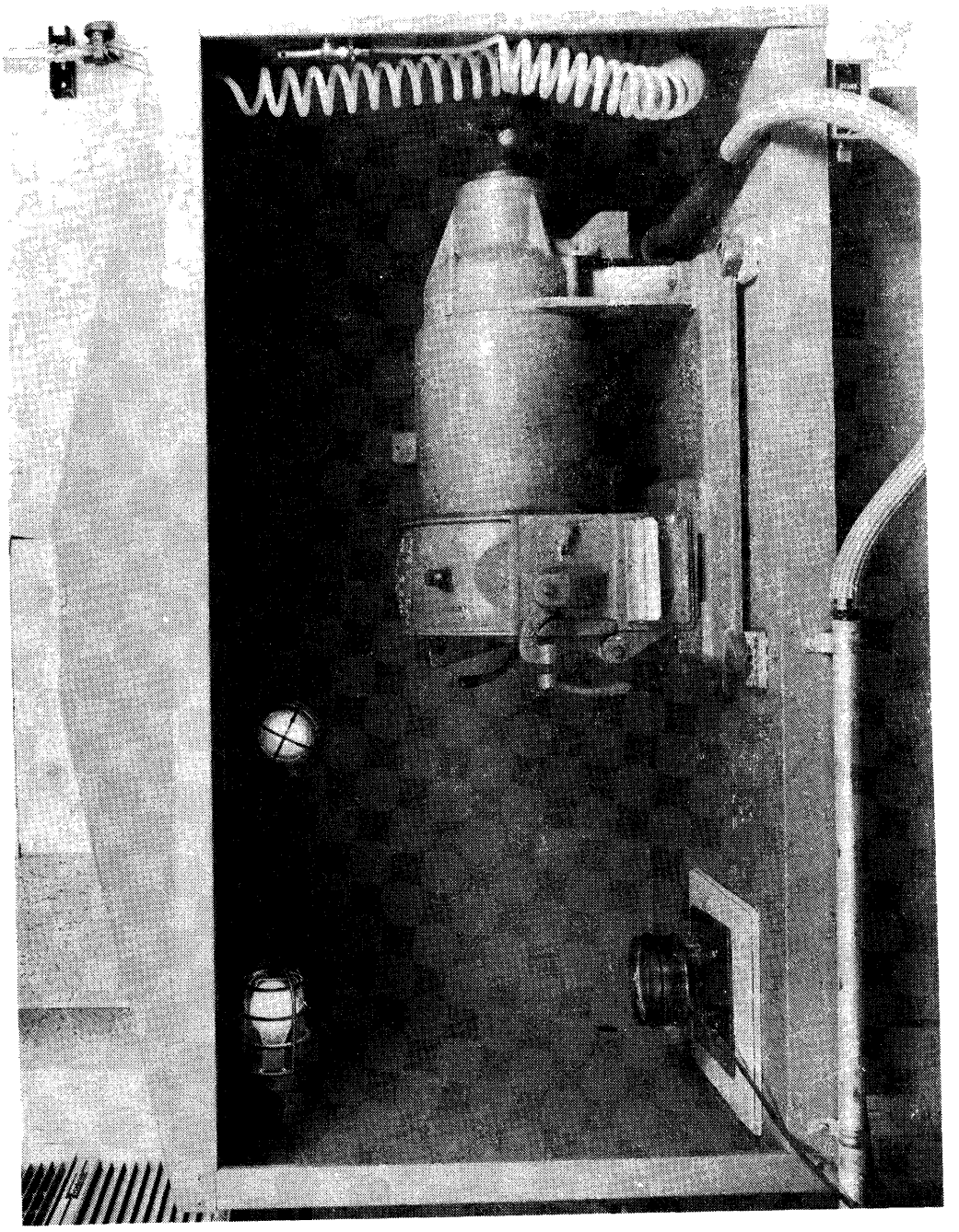


Exhibit 15.17. Photograph of pulverizer, sample vibrator, and hood.



16. EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

SUBJECT: EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

16. EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

16.1 MOBILE LABORATORY EQUIPMENT INVENTORY

16.1.1 Purpose

The purpose of this procedure is to establish a minimum inventory of equipment and supplies for the mobile laboratories and provide a method for maintaining the minimum inventory levels.

16.1.2 Applicability

This procedure applies to all mobile survey laboratories used in the ORNL-RASA program.

16.1.3 References

None.

16.1.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

16.1.5 Responsibilities

16.1.5.1 Site Leader

The site leader is responsible for the implementation of this procedure.

16.1.6 Procedure

16.1.6.1 Mobile Laboratory

The mobile lab coordinator ensures that the vehicle is in proper operating condition before it leaves ORNL and that all servicing has been completed according to ORNL garage scheduled maintenance.

16.1.6.2 Equipment

Before the lab leaves ORNL, the site leader conducts an inventory of the equipment and supplies on the mobile laboratory. The quantities of each item are compared with those of the equipment list and any deficiencies are brought up to standard inventory level prior to departure on a field assignment.

16.2 EQUIPMENT MAINTENANCE LOGS

16.2.1 Purpose

The purpose of this procedure is to describe the maintenance logs for instruments, equipment, and vehicles used in the ORNL-RASA program and to define the requirements for maintenance entries into appropriate log books for ORNL-RASA maintained instruments and equipment.

16.2.2 Applicability

This procedure applies to all maintained instruments, equipment, and vehicles utilized in the ORNL-RASA program.

16.2.3 References

None.

16.2.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

16.2.5 Responsibilities

The ORNL-RASA program manager is responsible for the implementation of this procedure, and the instrument technologist performing the maintenance function on ORNL-RASA maintained instruments and equipment is responsible for incorporating the maintenance entry into the appropriate log book.

16.2.6 Procedure

Maintenance logs for maintained equipment include three categories:

1. Vehicle maintenance logs,
2. I&C calibrated instrument maintenance logs, and
3. ORNL-RASA maintained instrument logs.

16.2.6.1 Vehicle Maintenance Logs

All vehicle maintenance is entered into a log book maintained and controlled by the ORNL garage. The ORNL garage facility has total responsibility for entering service, maintenance, and repairs into the appropriate log book.

16.2.6.2 I&C Calibrated Instrument Maintenance Log

All I&C calibrated instrument maintenance is entered into a log book maintained and controlled by ORNL I&C. The ORNL I&C facility has total responsibility for entering service, maintenance and repairs into the

appropriate log book. I&C calibrated instruments include: Alpha Scintillators, Gas Flow Proportional Alpha Counters, Geiger-Mueller Survey Meters, Beta-Gamma Pancake Counters, Pressurized Ion Chambers, Portable Gamma Scintillation Detectors, Mass Scales, Electronic Test Equipment, and Wet and Dry Test Meters.

16.2.6.3 ORNL-RASA Maintained Instrument Logs

ORNL-RASA maintained equipment and instruments

ORNL-RASA maintained instruments and equipment include all instruments and equipment not covered in Sects. 6.1 and 6.2 of this procedure. ORNL-RASA personnel also perform minor maintenance functions on instruments and equipment covered under Sect. 6.2 of this procedure.

Log book entries

Following the maintenance function, the instrument technologist will enter into the Calibrated Instrument Log Book, maintained at the ORNL-RASA laboratory, the following information as a minimum:

1. Date
2. A brief description of the service or repair work performed
3. Signature or mark uniquely traceable to the instrument technologist
4. Next scheduled service date

16.3 EQUIPMENT CALIBRATION RECORDS

16.3.1 Purpose

The purpose of this procedure is to describe the equipment calibration records maintained by ORNL-RASA for instrumentation used in the ORNL-RASA program.

16.3.2 Applicability

This procedure applies to all instrument calibration records maintained by ORNL-RASA in support of the ORNL-RASA program.

16.3.3 References

Sect. 20, Measuring and Test Equipment Calibration

16.3.4 Definitions and Abbreviations

16.3.4.1 Definitions

See Sect. 1.5 of this manual, Terminology.

16.3.4.2 Abbreviations

EOSD ORNL Environmental and Occupational Safety Division

Also see Sect. 1.5 of this manual, Terminology.

16.3.5 Responsibilities

1. The ORNL-RASA program manager is responsible for the implementation of this procedure.
2. The instrument technologist is responsible for the entry of calibration data into the calibration records (except Calibrated Instrument File).
3. The records technologist is responsible for the entry of data into the Calibrated Instrument File and for the maintenance of the file to ensure retrievability of data.

16.3.6 Procedure

ORNL-RASA maintains two calibration data bases for calibrated instruments, as follows: the Calibrated Instrument File and the log book calibration entries.

16.3.6.1 Calibrated Instrument File

The Calibrated Instrument File is organized and maintained in a data retrievable manner by the records technologist at the ORNL-RASA facility.

Instrument calibration data included in the Calibrated Instrument File include all ORNL-EOSD laboratory calibrations on the following instruments:

1. Alpha scintillators
2. Gas flow proportional alpha counters
3. Geiger-Mueller survey meters
4. Beta-gamma pancake counters
5. Rascal ratemeter
6. Gamma scintillation detectors
7. Mass scales
8. Wet and dry test meters

Following calibration, upon return of the instrument, the instrument technologist verbally notifies the records technologist of the arrival of calibrated instrument(s). The records technologist records the calibration data from the calibration sticker placed on the instrument(s) by ORNL-EOSD and enters the information in the Calibrated Instrument File.

Instruments calibrated by the ORNL-RASA instrument technologist that are included in the Calibrated Instrument File are:

1. Lucas cells
2. ORNL cells
3. Mass flow meters
4. Wrenn chambers

Following calibration, the instrument technologist supplies copies of the calibration data to the records technologist for inclusion in the Calibrated Instrument File. Calibrated data requirements are contained in the individual calibration procedures for the appropriate instrument (see Sect. 20 of this manual, Measuring and Test Equipment Calibration).

16.3.6.2 Log Book Calibration Entries

Calibration information is entered in appropriate log books located at the ORNL-RASA facility and at survey sites as follows:

1. Alpha Smear Counter Log Book. One log book exists for each unit (located on the mobile laboratory);
2. Beta-Gamma Smear Counter Log Book. One log book exists for each unit (located on the mobile laboratory);
3. Na(I) Detector Log Book. One log book exists for each unit (located on the mobile laboratory);
4. Portable Instrument Log Book used for field check data (located on each mobile laboratory);
5. Air Pump and Mass Flow Meter Calibration Log Book (located at the ORNL-RASA laboratory);
6. Wrenn Chamber Calibration Log Book (located at the ORNL-RASA laboratory); and
7. ORNL Cell and Lucas Cell Calibration Log Book (located at the ORNL-RASA laboratory).

Calibration data requirements are contained in the individual calibration procedures for the appropriate instrument (see Sect. 20 of this manual, Measuring and Test Equipment Calibration).

16.4 NEW EQUIPMENT CERTIFICATION

16.4.1 Purpose

The purpose of this procedure is to provide a method to ensure that all new equipment is certified to meet intended performance specifications prior to initial use in the ORNL-RASA program.

SUBJECT: EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

16.4.2 Applicability

This procedure applies to all new equipment and instrumentation to be utilized in the ORNL-RASA program. The instrumentation and equipment include commercially available, custom made, and ORNL prototype devices.

16.4.3 References

Sect. 19.4, Procedure Preparation

16.4.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

16.4.5 Responsibilities

The ORNL-RASA manager is responsible for the implementation of this procedure, and the instrument technologist is responsible for performance of this procedure.

16.4.6 Procedure

Instrumentation and equipment requiring certification fall into two general classes as follows:

1. Instrumentation and test equipment (commercial construction, including factory modifications)
2. Prototype instrumentation and equipment (including vendor and ORNL construction)

16.4.6.1 Instrumentation and Test Equipment

Prior to use in the ORNL-RASA program, all new instrumentation and test equipment is taken by the instrument technologist to ORNL I&C. The I&C personnel apply a marking (label, etc.) to the device including a unique I&C control number. A preliminary check is made of the device to ensure conformance to design specifications and performance requirements. Maintenance and calibration records are established by the I&C control number. Modifications should be documented on the instrument by I&C, with record of the modification maintained by ORNL-RASA. The device is calibrated according to the appropriate I&C calibration procedure.

Following successful completion of the testing and calibration, the device is returned to ORNL-RASA for use. If, however, the device fails any required performance test or fails to meet design specifications, the device is returned to ORNL-RASA with a notation to that effect. ORNL-RASA disposition options of the nonconforming device include: return to vendor for repair, return to vendor for exchange, return to vendor for credit, or return to ORNL for repair. The disposition option exercised is dependent on a series of judgment factors unique to each situation.

16.4.6.2 Prototype Instrumentation and Equipment

All prototype instrumentation and equipment has its own set of design specifications, performance requirements, and acceptance criteria established prior to device construction. Following completion of the device construction, the instrument technologist determines if assistance external to ORNL-RASA will be required to verify that the device conforms to previously determined acceptance criteria.

If external assistance is required, the instrument technologist makes all necessary arrangements with the appropriate organization internal or external to ORNL to verify conformance with the acceptance criteria. If external assistance is not required, the instrument technologist performs all testing and calibration necessary to verify that the prototype device meets the acceptance criteria. If the development of a specific calibration procedure is required, see Procedure Preparation, Sect. 19.4. Following successful completion of the testing, the device is placed in service, and calibration and maintenance records are generated, if appropriate.

If the prototype device fails to meet acceptance criteria, ORNL-RASA disposition of the nonconforming device may include: repair, redesign, and construction to meet established acceptance criteria; re-evaluation of acceptance criteria based on operational needs for the device; or abandonment of the device.

SUBJECT: EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

Exhibit 16.1. Mobile laboratory equipment inventory levels.

Item	Quantity required	Quantity on hand	Supplies needed
	Supplies		
Air sampler filters	1 box	_____	_____
Glassine envelopes	160 ea	_____	_____
Smears	150 ea	_____	_____
2 in. yellow pressure sensitive tape	12 rolls	_____	_____
Grey electrical tape	3 rolls	_____	_____
Orange flagging tape	2 rolls	_____	_____
Large plastic bags (garbage type)	1 roll	_____	_____
2 qt. plastic bags	1 box	_____	_____
"Turkey bags" (large plastic)	200 ea	_____	_____
Utility wipes	6 boxes	_____	_____
Kleenex	3 boxes	_____	_____
Vaseline	1 jar	_____	_____
Hand lotion	1 bottle	_____	_____
Zinc sulfide mylar film	6 replacements	_____	_____
Water sample bottles	48 ea	_____	_____
"D" cell batteries (Duracell)	24 ea	_____	_____
Gel cell batteries	3 ea	_____	_____
Gloves, leather (small)	6 pair	_____	_____

SUBJECT: EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

Exhibit 16.1. (Continued).

Item	Quantity Required	Quantity On hand	Supplies Needed
Gloves, leather (medium)	6 pair	_____	_____
Gloves, leather (large)	6 pair	_____	_____
Gloves, cotton (one size)	12 pair	_____	_____
Gloves, rubber (one size)	12 pair	_____	_____
Office Supplies and Forms			
Finger cotts	1 box	_____	_____
Shipping labels	1 box (roll)	_____	_____
Indoor data sheets	100 ea	_____	_____
Outdoor data sheets	100 ea	_____	_____
3 in. paper tape (computer)	2 rolls	_____	_____
Strapping tape	6 rolls	_____	_____
Masking tape (2 in. wide)	6 rolls	_____	_____
Scotch tape	2 rolls	_____	_____
Ball point pens	36 ea	_____	_____
Black sharpies (fine line pens)	2 boxes	_____	_____
Log book - large (300 pages)	2 ea	_____	_____
Log book - small (150 pages)	2 ea	_____	_____
Lined paper pads (8-1/2 x 11)	6 ea	_____	_____

SUBJECT: EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

Exhibit 16.1. (Continued).

Item	Quantity required	Quantity on hand	Supplies needed
Section pads (8-1/2 x 11)	6 ea	_____	_____
Section pads (11 x 17)	6 ea	_____	_____
Buddy pads	6 pads	_____	_____
Drafting paper (17 x 23)	25 sheets	_____	_____
Mechanical drafting pencil leads (0.05 mm)	1 box	_____	_____
Drafting pencils	6 ea	_____	_____
Lead holders	1 box	_____	_____
Ink (black)	1 bottle	_____	_____
Staples	1 box	_____	_____
Stapler	1 ea	_____	_____
Paper clips	1 box	_____	_____
	Equipment		
ORNL cells	6 ea	_____	_____
Air sampler	1 ea	_____	_____
Photographic equipment	1 ea	_____	_____
BNC connectors	24 ea	_____	_____
Spare scintillator cables	6 ea	_____	_____
Tape dispensers	2 ea	_____	_____
Yellow nylon rope	100 ft	_____	_____
Battery pack	3 ea	_____	_____

SUBJECT: EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

Exhibit 16.1 (Continued).

Item	Quantity required	Quantity on hand	Supplies required
Leroy lettering set	2 ea	_____	_____
Triangles 45°	2 ea	_____	_____
Triangle 30-60-90	2 ea	_____	_____
Pencil pointer	1 ea	_____	_____
Pens 00-2 (Rapidio)	2 set	_____	_____
Adjustable curve	1 ea	_____	_____
0.05 mm mechanical pencil	3 ea	_____	_____
Electric eraser	1 ea	_____	_____
Transit (only one available)	1 ea	_____	_____
Tripod (only one available)	1 ea	_____	_____
Water sampler	1 ea	_____	_____
Rain boots (1 per crew member)	4 ea	_____	_____
Rain hat (1 per crew member)	4 ea	_____	_____
Rain pants (1 per crew member)	4 ea	_____	_____
Rain coats (1 per crew member)	4 ea	_____	_____
Tools			
Electronics tool kit	1 ea	_____	_____
30-m crank tape	2 ea	_____	_____
3-m tape	3 ea	_____	_____

SUBJECT: EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

Exhibit 16.1 (Continued).

Item	Quantity required	Quantity on hand	Supplies required
	Tools (continued)		
100 ft tapes	2 ea	_____	_____
10 ft tapes	2 ea	_____	_____
Posthole digger	1 ea	_____	_____
Shovel (long-handle, round point)	1 ea	_____	_____
Pick	1 ea	_____	_____
Scoops (sampling)	2 ea	_____	_____
Buckets	12 ea	_____	_____
Hand tools	1 tool chest	_____	_____
	Vehicle		
Mobile laboratory keys	3 sets	_____	_____
U.S. government credit card	1 ea	_____	_____
	Instrumentation		
Simpson meter (VOM)	1 ea	_____	_____
Gamma scintillators/ headphones	6 ea	_____	_____
Beta-gamma instruments	6 ea	_____	_____
Alpha gas flow meters	2 ea	_____	_____
Alpha scintillators	4 ea	_____	_____
Logging scaler	2 ea	_____	_____
Logging cables	2 ea	_____	_____

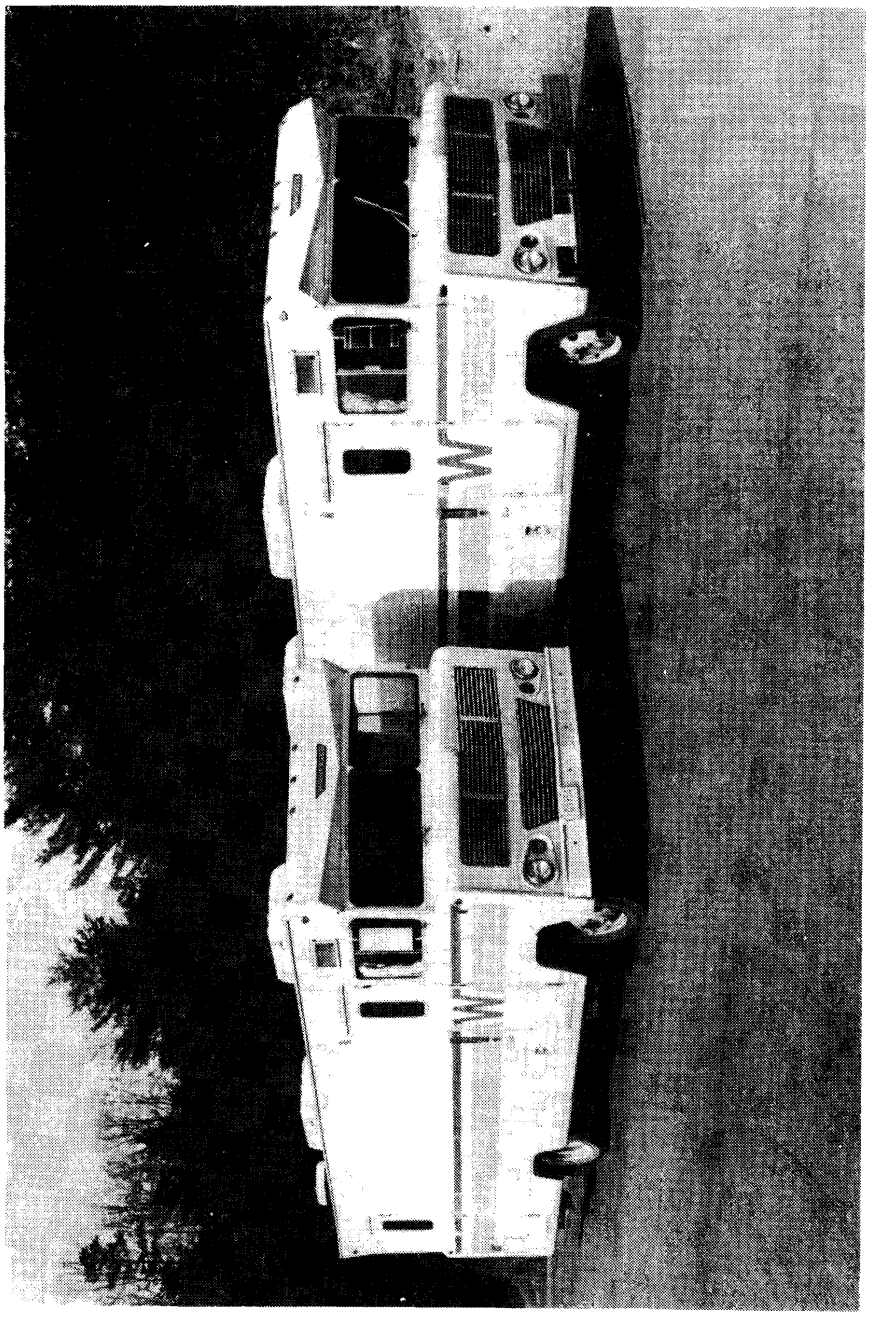
SUBJECT: EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

Exhibit 16.1. (Continued).

Item	Quantity required	Quantity on hand	Supplies required
	Instrumentation (continued)		
Logging shielded scintillator	1 ea	_____	_____
Logging tripod	1 ea	_____	_____
Pressurized ion chamber	1 ea	_____	_____
Wrenn chambers	(Optional)	_____	_____
	Calibration sources[a]		
	Manuals		
RASA Procedures Manual	1 ea	_____	_____
Instrumentation manuals	1 ea/instrument type	_____	_____
Includes survey, electronic instrumentation, and system component manuals (linear amplifier, power supply, etc.)			

[a]See procedures for appropriate instrumentation to determine which field check sources to include in inventory.

Exhibit 16.2. Photograph of ORNL-RASA mobile laboratories.



17. MONITORING AND DECONTAMINATION

SUBJECT: MONITORING AND DECONTAMINATION

17. MONITORING AND DECONTAMINATION

17.1 INSPECTION OF EQUIPMENT AND PERSONNEL FOR CONTAMINATION

17.1.1 Purpose

The purpose of this procedure is to provide guidelines for inspection of equipment and personnel for radioactivity.

17.1.2 Applicability

This procedure applies to inspection for contamination of equipment and personnel at RASA sites being surveyed by ORNL-RASA personnel.

17.1.3 References

1. Sect. 13.2, Alpha Radiation Measurements
2. Sect. 13.3, Beta-Gamma Radiation Measurements
3. Sect. 13.4, Transferable Alpha and Beta-Gamma Measurements
4. Sect. 13.6, External Gamma Radiation Measurements
5. Sect. 17.3, Decontamination of Equipment and Personnel

17.1.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

17.1.5 Responsibilities

17.1.5.1 ORNL-RASA Manager

The ORNL-RASA manager is responsible for the implementation of this procedure.

17.1.5.2 Site Leader

The site leader is responsible for implementation of this procedure at the survey site.

17.1.5.3 Instrument Technologist

The instrument technologist is responsible for performing the contamination inspection according to this procedure.

17.1.6 Procedure

17.1.6.1 Introduction

To determine if personnel or equipment involved or used in the survey activities have become contaminated, skin, clothing, shoes, and equipment surfaces are scanned with portable instruments for measuring gross alpha, beta, and gamma radiation.

17.1.6.2 Inspection for Alpha Contamination

To determine if alpha contamination is present, scan suspect equipment or personnel with the portable alpha scintillation detector. The operation of these instruments is described in Sect. 13.2, Alpha Radiation Measurements. If contamination is found, follow Sect. 17.3, Decontamination of Equipment and Personnel.

17.1.6.3 Inspection for Beta-Gamma Contamination

To inspect equipment and personnel for beta-gamma activity, scan with the portable beta-gamma GM survey detectors. The operation of these instruments is described in Sect. 13.3, Beta-Gamma Radiation Measurements. Use the open and closed window modes of the probe to determine relative contributions of beta or gamma radiation to the contamination. If contamination is found, follow the procedure of Sect. 17.3, Decontamination of Equipment and Personnel.

17.1.6.4 Inspection for Gamma Contamination

To inspect equipment and personnel for gamma activity, scan with the portable gamma scintillator detectors. The operation of these instruments is described in Sect. 13.6, External Gamma Radiation Measurements. If contamination is found, follow the procedure of Sect. 17.3, Decontamination of Equipment and Personnel.

17.1.6.5 Inspection for Transferable Alpha and Beta-Gamma Contamination

To check for transferable contamination on equipment, take standard smear samples as described in Sect. 13.4, Transferable Alpha and Beta-Gamma Measurements. These smears are counted and evaluated as described by that procedure. If contamination is found, follow the procedure of Sect. 17.3, Decontamination of Equipment and Personnel.

17.1.6.6 Documentation

The results of the contamination survey of personnel and equipment are entered into the Site Field Data Log Book. If any decontamination is required, the actions taken and the results of these actions should also be included in the log book.

SUBJECT: MONITORING AND DECONTAMINATION

17.2 DECONTAMINATION OF EQUIPMENT AND PERSONNEL

17.2.1 Purpose

The purpose of this procedure is to describe the method for decontamination of equipment and personnel at ORNL-RASA survey sites.

17.2.2 Applicability

The procedure applies to the decontamination of equipment and personnel involved in activities under the ORNL-RASA program.

17.2.3 References

1. Sect. 17.1, Inspection of Equipment and Personnel for Contamination
2. Series D-5-1, Contamination or Damage to Personal Property, Martin Marietta Energy Systems, Inc., Standard Practice Procedures

17.2.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

17.2.5 Responsibilities

17.2.5.1 Site Leader

The site leader is responsible for the implementation of this procedure. He will ensure that contaminated personnel are promptly decontaminated; contaminated equipment is either isolated for subsequent decontamination or decontaminated at the site.

17.2.5.2 Team Member

Any team member designated to decontaminate equipment or personnel will follow this procedure.

17.2.6 Procedure

17.2.6.1 Contamination Determination

The presence of contamination on personnel or equipment is determined by scanning with portable radiation instruments. Depending on the types of radiation encountered in the survey, appropriate portable instruments are used. Refer to Sect. 17.1, Inspection of Equipment and Personnel for Contamination, for details.

17.2.6.2 Contamination Criteria

A person or equipment is considered contaminated if the measured surface activity exceeds the following general guidelines:

1. Direct alpha activity - 150 dpm/100cm[1]
2. Direct beta-gamma activity - 1,000 dpm/100cm[2]
3. Transferable alpha activity - 20 dpm/100 cm[2]
4. Transferable beta-gamma activity - 200 dpm/100 cm[2]

17.2.6.3 Decontamination Procedure

Equipment

When ORNL-RASA equipment is contaminated, wipe it with a wet paper towel or wash with water, if applicable. Scan with the appropriate radiation detector after wiping or washing. Repeat the procedure if necessary. If the residual activity is below guideline values, the equipment can be reused; if not, place the equipment in a plastic bag, seal, and mark "contaminated equipment." Store together with other contaminated equipment for subsequent decontamination at ORNL. Note in the Portable Instrument Log Book the instruments or equipment to be sent for decontamination. Collect the materials used for decontamination and dispose of as low level wastes through Applied Health Physics at ORNL.

Radiation instruments used by ORNL-RASA personnel in survey activities rarely become contaminated. If they do, the contamination is expected to be minimal and can be eliminated by wiping with moist disposable paper towels. If for some reason instruments have persistent contamination, they are brought back to ORNL for decontamination. Contaminated subcontractor equipment may include augers and samplers and such implements as picks, shovels, trowels, buckets, etc.

When contamination is found, the equipment is cleaned of adhering materials and washed with water. It is then scanned with the same portable radiation instrument that was used to inspect for contamination. If the residual activity is below the applicable guideline values, the equipment is considered "clean" and may be reused without further action. For persistent contamination on contractor equipment, the site leader will contact a steam-cleaning subcontractor to clean the contractor's equipment onsite.

Personnel

Personnel involved with site survey activities include subcontractor personnel and ORNL-RASA survey team members.

Subcontractors are advised of potential radioactivity contamination and attendant radiation exposures. However, ORNL-RASA personnel provide a limited monitoring of subcontractor personnel and equipment. When the expected contamination is low, subcontractors are advised to bring water to wash off

slight contamination of equipment. Slightly contaminated subcontractor personnel clothing and apparel are retained by the site leader with reasonable monetary reimbursement for the contaminated clothing materials. The retained materials are brought back to ORNL and disposed of as low-level radioactive waste. ORNL-RASA will, at its discretion, provide clothing for use onsite if conditions warrant.

ORNL-RASA personnel monitor and decontaminate themselves at the site. Personnel decontamination involves changing clothing and washing with soap and water repeatedly until the contamination is below the guideline values.

Where contamination is anticipated, ORNL-RASA personnel are issued company protective or disposable anticontamination apparel for their protection. In cases where personal apparel is contaminated, the contaminated clothing materials are retained and disposed of in the same manner as subcontractor contaminated clothing. Reimbursement of personal effects for ORNL-RASA personnel is according to Sect. D-5-1 of the Martin Marietta Energy Systems, Inc. D Series Standard Practice Procedure.

17.3 PERSONNEL EXPOSURE MONITORING AND PROTECTION

17.3.1 Purpose

The purpose of this procedure is to outline existing ORNL-RASA requirements for personnel exposure monitoring.

17.3.2 Applicability

This procedure applies to all ORNL-RASA personnel and subcontractors who are exposed to contaminated materials at the Laboratory or in the field at survey sites.

17.3.3 References

1. Sect. 17.3, Decontamination of Equipment and Personnel
2. Health Physics Manual, Procedures and Practices for Radiation Protection, Martin Marietta Energy Systems, Inc. Procedure 3.0, Personnel Exposure Control
3. D-5-27, Standard Practice Procedure, Radiation Monitoring for Non-employees

17.3.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

SUBJECT: MONITORING AND DECONTAMINATION

17.3.5 Responsibilities

1. ORNL-RASA personnel radiation exposure monitoring is provided by the Martin Marietta Energy Systems Environmental and Occupational Safety Division (EOSD). The individual personnel monitors are submitted annually to EOSD for interpretation of the accumulated dose and for entry into permanent records.
2. The EOSD maintains all ORNL-RASA group personnel exposure records.
3. In the field, RASA subcontractors are responsible for their personnel exposure monitoring equipment and protection.

17.3.6 Procedure

1. The site leader advises the subcontractors in the statement of work for each contract that their activities may be conducted in potentially contaminated areas.
2. In the field, the ORNL-RASA personnel may take a direct alpha count for contamination of all contractor personnel clothing and equipment at the end of each work day. Smears of equipment are also taken to determine the extent of removable contamination. Under certain conditions, the site leader may issue contracted personnel boots and other clothing for their use in contaminated areas. This clothing remains ORNL property and does not leave the work site. Proper decontamination/disposal of the clothing is provided by ORNL personnel.
3. If contamination is observed on contractor equipment or clothing, decontamination and/or replacement of the items will be provided by Martin Marietta Energy Systems as specified in the contract. Decontamination procedures are outlined in Sect. 17.3, Decontamination of Equipment and Personnel.
4. At the end of each day or when equipment or contractor personnel leave the site, the site leader enters in the site log book a record that personnel and equipment have been checked and are free of radioactive contamination and gives details of the decontamination practices employed (if any were required).

18. SUBCONTRACT SERVICES AND ADMINISTRATION

18. SUBCONTRACT SERVICES AND ADMINISTRATION

18.1 PROCUREMENT OF SERVICES AND EQUIPMENT

18.1.1 Purpose

The purpose of this procedure is to provide complete information and sources to enable procurement of services and equipment outside of the Oak Ridge National Laboratory.

18.1.2 Applicability

18.1.2.1 Services

This procedure is applicable to ORNL-RASA technical staff (e.g., site leaders) having the responsibility of performing formal radiological survey(s) at a remote site or requiring other technical subcontractor services. Typical subcontractual needs may include:

1. Industrial cleaners for clearing and cleaning of buildings before indoor surveys are begun
2. Landscape maintenance for clearing vegetation and rubble before the outdoor surveys are made
3. Land surveyors for establishing measurement grid system, property lines, and preparing base maps for use in documentation of survey results
4. Construction contractors for earth and large debris removal (i.e. backhoe, caterpillar, front-end loader, etc.) to improve site accessibility
5. Drilling and auger contractors to provide drilling services for subsurface sampling, including augering and continuous core sampling, as part of onsite surveys
6. Technical support for obtaining technicians and professional radiological health personnel to conduct radiological surveys or for other RASA technical needs

18.1.2.2 Equipment

Purchase of necessary equipment for operation of group functions.

18.1.3 References

1. Sect. 8.1, Identification and Planning of Support Functions
2. ORNL/CF-79/53, Guidelines for Subcontracting at ORNL.
3. D-2-16, Standard Practice Procedure Martin Marietta Energy Systems, Quality Assurance Program
4. D-2-16S, ORNL Supplement, Standard Practice Procedure Martin Marietta Energy Systems, Quality Assurance Program
5. D-2-8, Standard Practice Procedure Martin Marietta Energy Systems, Consultant and Special Services
6. D-2-8S, ORNL Supplement Standard Practice Procedure Martin Marietta Energy Systems, Consultant and Special Services
7. D-2-1, Standard Practice Procedure Martin Marietta Energy Systems, Procurement of Material
8. Martin Marietta Energy Systems Purchasing Division Manual

18.1.4 Definitions and Abbreviations

18.1.4.1 Definitions

SUBCONTRACTS. Written agreements between the company and others to obtain (1) consultant service, (2) research and development services, and (3) other professional and technical services.

Also see Sect. 1.5 of this manual, Terminology.

18.1.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

18.1.5 Responsibilities

18.1.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for the overall management of all contracts required for the program.

18.1.5.2 Technical Staff Member

Services

A technical staff member assigned by the ORNL-RASA program manager is responsible for the following duties when procuring out-of-laboratory services:

1. Services requiring Form UCN-1127, Request for Individual Consultant or Research and Development Subcontract:

   a. Initiates subcontract request (Form UCN-1127, Exhibit 18.1),
   b. Expedites approval (see Exhibits 18.4 and 18.5),
   c. Provides technical work statements and related cost estimate,
   d. Provides sole-source justifications, as required,
   e. Interfaces with ORNL Subcontracts Coordinator as to type of contract and final QA function,
   f. Assists Purchasing in evaluation of vendor proposals (if using Subcontracts Form UCN-1127), and
   g. Serves as source for any technical documents required.

2. Services requiring Form UCN-3324, Purchase Order Form:

   a. Initiates Purchase Order Form (see Example UCN-3324, Exhibit 18.6),
   b. Expedites approval. Sign-off will be obtained from (1) ORNL-RASA program manager, (2) Dosimetry and Biophysical Transport Section Leader, and (3) HASRD Director and
   c. Forwards form to Division Finance Office for review and submission to Purchasing Division.

Equipment

The technical staff member is responsible for the following when procuring equipment:

1. Initiates Purchase Order Form (see Example UCN-3324, Exhibit 18.7);
2. Expedites approvals. Purchase Order Form requires sign-off by (a) ORNL-RASA program manager, (b) Dosimetry and Biophysical Transport Section Leader, and (c) HASRD Director; and
3. Forwards form to Division Finance Officer for review and submission to Purchasing Division.

18.1.5.3 Martin Marietta Energy Systems Procurement

1. Martin Marietta Energy Systems Procurement Department negotiates vendor rates and fees and writes the body of the subcontract.
2. Initiates consultant contract renewal using Form UCN-1226.
3. Determines winner of bids on Purchase Order Form UCN-3324 for services or equipment (Exhibit 18.3), and notifies ORNL-RASA.

18.1.6 Procedure

The procedure for using Form UCN-1127 (Exhibit 18.1), Request for Individual Consultant or Research and Development Contract Services, applies here.

18.1.6.1 Statement of Work

The technical staff member will prepare a detailed statement of work that can meet the needs of the job and cannot be accomplished with ORNL capabilities. This statement of work will form the basis of the body of a subcontract written by the Procurement Division.

18.1.6.2 Initiation of Subcontract

The technical staff member who initiates a subcontract will refer to the ORNL standard procedures for purchasing and subcontracting. See all references. The formal procedure guide source is the Martin Marietta Energy Systems Purchasing Division Manual, and a general guideline for subcontracting is "Guidelines for Subcontracting at ORNL," ORNL/CF-79/53.

18.1.6.3 Subcontract Preparation Participants

ORNL-RASA technical staff member

Follow the guidelines (Ref. 2, Sect. 18.1.3) for establishing the subcontract. Interfaces will be made with the Division Finance Officer, the ORNL Subcontract Coordinator, and the Procurement Division.

Division finance officer

The Division Finance Officer provides assistance in the preparation of Form UCN-1127, Request for Individual Consultant or Research and Development Subcontract. (See Exhibit 18.1.)

ORNL subcontract coordinator

The ORNL Subcontract Coordinator assists the technical staff member in the preparation of a descriptive statement of work adequate for needs of the Procurement Division. This statement will clearly and completely describe the work to be done for a definitive contract to be written and provide a legal basis for defining completion of the work and approval of payments to the vendor. Other considerations such as sole-source justification will be discussed with the coordinator, documented, and attached to the request.

The coordinator also provides counsel to the technical staff member regarding type of contract best suited for the task and, generally, the entire procedure to finalize the subcontract. He also provides a quality control function for the completed request before it is submitted to Martin Marietta Energy Systems Procurement. This quality control function generally consists of ensuring that all applicable ORNL requirements have been met and included in the subcontractor request documents. He should also be involved in any problems arising with administration of on-going contracts.

Purchasing agent, Martin Marietta Energy Systems, Inc.

Counsel with the purchasing agent is helpful during the formative discussions about a subcontract, especially in determination of contract type. He can help identify the content of supporting documents to accompany Form UCN-1127 and can work through the ORNL Subcontract Coordinator to identify the proper purchasing agent to contact.

18.1.6.4 ORNL Subcontract Approval Requirements

Subcontracts create a legally binding obligation of federal funds, and, therefore, Federal Procurement Regulations and other federal policies and regulations must be followed. Designated approvals must be obtained. (See Exhibit 18.4.) Nominal processing time of the initiating documents is shown in Exhibit 18.5.

18.1.6.5 Procedure for Using Form UCN-3324, Purchase Order Form for Services or Equipment

Use of Form UCN-3324 (See Exhibit 18.3.)

This form is used for:

1. Purchase of necessary equipment and materials
2. Obtaining onsite services such as drilling, land surveyor gridding, landscape maintenance, industrial cleaners, and construction contractors

ORNL-RASA technical staff member actions

The ORNL-RASA technical staff member:

1. Prepares form UCN-3324, Exhibit 18.3, and any required technical specifications
2. Obtains approval sign-offs
3. Submits to Procurement Division via Division Finance Officer.

Award

The Procurement Division selects the winning bidder and informs the ORNL-RASA group.

18.2 ADMINISTRATION OF SUBCONTRACTS

18.2.1 Purpose

The purpose of this procedure is to establish the requirements and responsibilities of ORNL-RASA technical staff members for administering an active subcontract.

SUBJECT: SUBCONTRACT SERVICES AND ADMINISTRATION

18.2.2 Applicability

This procedure applies to all subcontracts initiated for support of the work and functions of the ORNL-RASA program.

18.2.3 References

1. Sect. 18.3, Subcontractor Reporting
2. ORNL/CF-79/53, Guidelines for Subcontracting at ORNL
3. D-2-16, Standard Practice Procedure, Martin Marietta Energy Systems, Quality Assurance Program
4. D-2-8, Standard Practice Procedure, Martin Marietta Energy Systems, Consultant and Special Services
5. Martin Marietta Procurement Division Manual

18.2.4 Definitions and Abbreviations

18.2.4.1 Definitions

SUBCONTRACTS. Written agreements between the company and others to obtain (a) consultant services, (b) research and development services, and (c) other professional and technical services.

Also see Sect. 1.5 of this manual, Terminology.

18.2.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

18.2.5 Responsibilities

18.2.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager has the responsibility to ensure that all subcontracted work has adequate funding and that all subcontracted work is technically adequate within the defined scope of work.

18.2.5.2 Technical Staff Member

The technical staff member responsible for initiating the subcontract will be responsible for administrative tasks dealing with the subcontract.

18.2.6 Procedure

18.2.6.1 Technical Staff Member Actions

The technical staff member will perform these duties when administering the subcontract:

1. Prevent potential subcontractor from starting work in advance of official authorization from Martin Marietta Energy Systems Procurement.
2. Serve as the source of technical documents and direction for the subcontractor.
3. Provide Martin Marietta Energy Systems Procurement (via ORNL-RASA program manager) with confirmation of work done to enable vendor payments.
4. Interface with the ORNL-RASA program manager and ORNL Subcontracts Coordinator if problems arise in administration of the contract.
5. Initiate and provide technical support for subcontract modification when required.
6. Advise ORNL-RASA program manager of special year-end accounting problems when required. See Martin Marietta Energy Systems Procurement Division Manual.

18.2.6.2 Other Directives

1. The technical staff member will direct the technical performance of the vendor in required tasks. He will ensure that performance of the tasks is properly completed and that quality assurance has been effected according to the subcontract requirements. See D-2-16, Martin Marietta Energy Systems Quality Assurance Program.
2. The technical staff member should review ORNL/CF-79/53, Guidelines for Subcontracting at ORNL.
3. He will keep the RASA program manager informed of the status of the subcontracted job and follow any directives.
4. He will review and approve the subcontractor's final report. See Sect. 18.3, Subcontractor Reporting.

18.3 SUBCONTRACTOR REPORTING

18.3.1 Purpose

This procedure is for use by ORNL-RASA technical staff members for guidance in subcontractor contract report requirements.

18.3.2 Applicability

This procedure will be used to prepare every ORNL-RASA subcontractor contract and onsite services purchase order.

18.3.3 References

1. Sect. 4, Preliminary Survey Planning
2. Sect. 5, Vicinity Properties Survey Planning
3. Sect. 6, Candidate Site Survey Planning
4. Sect. 7, Postremedial Action Survey Planning
5. Sect. 11.3, Identification of Subcontractor Requirements
6. Sect. 18.1, Procurement of Services and Equipment

18.3.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

18.3.5 Responsibilities

The ORNL-RASA technical staff member will implement and comply with this procedure.

18.3.6 Procedure

18.3.6.1 Types of Subcontractors Reports

1. Letter Report
2. Environmental Impact Assessment and/or Statement
3. Radiological Survey Report
4. Drillers Report

18.3.6.2 General

The technical staff member will include in the contract for each subcontractor certain specifications and guidance for the reports he requires from them, such as:

1. The subcontractor will respond to schedule and all reporting requirements of his particular contract, including information such as driller's log, surveyor's maps, water sampling data, and subsurface data.
2. The subcontractor will respond to ORNL-RASA guidance during report preparation.
3. The subcontractor will respond to ORNL-RASA review comments of his report when provided.
4. Publication and distribution requirements will be stated in the contract. There may be certain property identification limitations per contract terms and conditions.
5. The subcontractor will use an ORNL-RASA specified format, or may use his own format to supply the required information, if acceptable to the technical staff member.

SUBJECT: SUBCONTRACT SERVICES AND ADMINISTRATION

Exhibit 18.1. Request for individual consultant or research and development subcontract (Form UCN-1127).

REQUEST FOR INDIVIDUAL CONSULTANT OR RESEARCH AND DEVELOPMENT SUBCONTRACT

INSTALLATION
- ☐ OAK RIDGE GASEOUS DIFFUSION PLANT
- ☐ OAK RIDGE NATIONAL LABORATORY
- ☐ OAK RIDGE Y-12 PLANT
- ☐ PADUCAH GASEOUS DIFFUSION PLANT

☐ APPLIED RESEARCH
☐ BASIC RESEARCH (REQUIRES PROGRAMMATIC DOE HDQTRS. APPROVAL)

Date	Division Name/ Code Number	Request Number

TO: PURCHASING DIVISION SUBCONTRACT SECTION

NAME AND ADDRESS OF CONSULTANT OR SUBCONTRACTOR:

Former Employee ☐ Yes ☐ No

☐ New Subcontract ☐ Renewal
☐ Modification ☐ Cancellation
☐ Establish Accrual (over)

Subcontract No. _____
Basic Order Agreemt. No. _____
Letter Release No. _____
Original Beginning Date _____
Current Exp. Date _____
Beginning Date This Proposal _____
Period Of Contract This Proposal _____

ATTACHMENTS:
- ☐ Sole Source Justification
- ☐ Technical Review
- ☐ Statement of Work
- ☐ Other _____

NUCLEAR MATERIAL REQUIRED:
☐ No ☐ Yes - Quantity and Form

SECURITY REQUIREMENTS

Will Restricted Data Be Transferred Outside Of Oak Ridge Or Paducah?	Will Consultant Or Subcontractor's Personnel Have Access To Restricted Data?	Will Consultant Or Subcontractor's Personnel Have Access To Exclusion Area?
☐ No ☐ Yes	☐ No ☐ Yes	☐ No ☐ Yes

COMPLETE THIS SECTION FOR INDIVIDUAL CONSULTANT OR PERSONAL SERVICES CONTRACT

☐ Personal Services ☐ Consultant	Citizenship	Account Charge -61-	B & R Number	FTP/A Number	Work Order Number

Employer			Justification For Rate Of Compensation
Position	Compensation	Highest Degree-YR.	
Maximum No. Days	Recommended Rate Per Day		MISC. EXPENSES ☐ No ☐ Yes - Itemize TRAVEL ALLOWANCE ☐ No ☐ Yes

COMPLETE THIS SECTION FOR R&D SUBCONTRACT

COMMITMENT (Including Fee)

					TOTAL
Work Order Number					
Account Charge					
B&R Number					
FTP/A Number					
Amount Previously Committed	$	$	$	$	$
Amount Committed This Proposal	$	$	$	$	$
Amount Uncommitted This Proposal	$	$	$	$	$
TOTAL	$	$	$	$	$

COST (Including Fee)

Amount Prior FYs	$	$	$	$	$
Amount This FY (Current)	$	$	$	$	$
Amount Future FYs	$	$	$	$	$
TOTAL	$	$	$	$	$

PURPOSE AND SCOPE OF SUBCONTRACT

APPROVALS:		Technical Contact	Date
Division Director	Date	Finance & Materials	Date
Assoc. Lab Director	Date	Installation Head	Date
Subcontract/Consultant Coordinator	Date	Purchasing Division	Date

UCN-1127 (238 3-82)

SUBJECT: SUBCONTRACT SERVICES AND ADMINISTRATION

Exhibit 18.2. Request for payment to guest lecturers or agreement for short-term consulting or professional services (Form UCN-237).

REQUEST FOR PAYMENT TO GUEST LECTURERS OR AGREEMENT FOR SHORT-TERM CONSULTING OR PROFESSIONAL SERVICES

INSTALLATION: ☐ ORGDP ☐ Y-12 ☐ ORNL ☐ PADUCAH
ORM 1201 ORM 1101 ORM 2101 ORM 1202
☐ Short-Term Consulting or ☐ Professional Service
☐ Guest Lecturer (Requires Signature of Individual on reverse side)

FORMER EMPLOYEE ☐ YES ☐ NO

DATE	TRAVEL ORDER NO.

I. REQUEST FOR PAYMENT

INDIVIDUAL'S NAME		SOCIAL SECURITY OR TAXPAYER'S ACCOUNT NUMBER	CHARGE ACCOUNT NUMBER
MAILING ADDRESS		ORGANIZATION REPRESENTED AND POSITION	B & R NUMBER
TRAVEL FROM	TO	REGULAR EMPLOYER CODE	AREA OF SPECIALIZATION
RETURN TO		FORMER EMPLOYER	FORMER EMPLOYER CODE
TRAVEL EXPENSES REQUESTED ☐ YES ☐ NO	IF YES, REIMBURSE ☐ UCN POLICY ☐ OTHER (SEE S.P.P.D-2-8)	SERVICES CATEGORY CODE	
HONORARIUM OR FLAT FEE REQUESTED ☐ YES ☐ NO	IF YES, TOTAL AMOUNT $	BEGINNING DATE / ENDING DATE	NUMBER OF DAYS
DAILY FEE REQUESTED ☐ YES ☐ NO	IF YES, RATE PER DAY $		

DAILY FEE TO			
	A.	☐ INCLUDE	☐ EXCLUDE TRAVEL TIME
	B.	☐ INCLUDE	☐ EXCLUDE WEEK ENDS

☐ CLASSIFIED INFORMATION INVOLVED
☐ NO CLASSIFIED INFORMATION INVOLVED

II. PURPOSE OF VISIT OR REMARKS (EXPLAIN FULLY)

III. ALIEN TAX CLASSIFICATION

If individual is a citizen of another country, part III must be completed prior to submission to travel office.

CITIZENSHIP	TYPE VISA

CHECK APPROPRIATE BOX ☐ RESIDENT ALIEN (1) ☐ NONRESIDENT ALIEN ☐ TAX TREATY WITHHOLDING EXEMPTION (2)

(1) IRS Form 1078, Certificate of Alien Claiming Residence in the U.S., must be completed in duplicate by the resident alien and submitted to the Travel Office prior to payment

(2) If nonresident aliens claim they should be exempted from withholding due to existing tax treaty conditions, they must submit a written statement to the Travel Office stating their claim and specifically indicating the number of days they 'have been' and 'will be' in the U.S. and the amount of their earnings in the U.S. to date.

NOTE IRS Regulations require UCN to withhold income tax from all honoraria or fees paid to nonresident aliens unless specifically exempted by tax treaty conditions.

IV. APPROVAL

DISTRIBUTION: Copies 1-3 Travel Section
Copy 4 Division Head

INSTALLATION HEAD OR DESIGNATED REPRESENTATIVE

UCN-237
(1235 2-83)

SUBJECT: SUBCONTRACT SERVICES AND ADMINISTRATION

Exhibit 18.3. Purchase Requisition Form (UCN-14715).

PURCHASE REQUISITION

NOTE: *HEAVY OUTLINED BOXES ARE REQUIRED ENTRIES*

Total Items	Page of

Requisition No.	Date Prepared	Wanted by Date	URGENCY	Urgency Approval Signature	Employee No.	Call-In
8- 5958			☐ Urgent ☐ Critical ☐ Routine			

INSPECTION	Special Inspection Name/Instructions	Code	HAZARDOUS No	Yes	U	Use Code	Hazard Employee No.
☐ Receiving ☐ Special							

Refer Technical Questions to: *(If different from requester)*		BM Number	Priority	DOD Program	Commodity Code
Name	Phone				

Suggested Vendor(s)	Attachments(s) Indicator(s):
	☐ 1. Classified ☐ 3. Specifications ☐ 5. Samples ☐ 7. Del. Sch. ☐ 2. Drawings ☐ 4. Sole Source ☐ 6. Controlled Subst. ☐ 8. Other
	Requester Identification/Justification

Remarks to Purchasing

Item No.	Acct., T.E., Sub. No., or W.O.	Deliver to Name	Location	Wanted by Date	Del. Schedule
001					☐ Attached

Hazard Code(s):	BM Item No.	Property Item	Replacement Parts for
H___F___R___A___S___		☐ Yes	

Noun	Vendor Part Number	Quantity	Unit	Est. Unit Price

Description

Item No.	Acct., T.E., Sub. No., or W.O.	Deliver to Name	Location	Wanted by Date	Del. Schedule
002					☐ Attached

Hazard Code(s):	BM Item No.	Property Item	Replacement Parts for
H___F___R___A___S___		☐ Yes	

Noun	Vendor Part Number	Quantity	Unit	Est. Unit Price

Description

Requester Signature	Requester Employee Number	Phone	Date
Installation Head or Authorization Representative Signature	Approval Employee Number	Date	

UCN-14715 (126 6-83)

SUBJECT: SUBCONTRACT SERVICES AND ADMINISTRATION

Exhibit 18.4. Purchase Requisition Continuation Page (UCN-14715A).

PURCHASE REQUISITION

(Continuation Page)

Requisition No.	Page of

Item No.	Acct., T.E., Sub. No., or W.O.	Deliver to Name	Location	Wanted by Date	Del. Schedule ☐Attached

Hazard Code(s): H___F___R___A___S___	BM Item No.	Property Item ☐Yes	Replacement Parts for

Noun	Vendor Part Number	Quantity	Unit	Est. Unit Price

Description

Item No.	Acct., T.E., Sub. No., or W.O.	Deliver to Name	Location	Wanted by Date	Del. Schedule ☐Attached

Hazard Code(s): H___F___R___A___S___	BM Item No.	Property Item ☐Yes	Replacement Parts for

Noun	Vendor Part Number	Quantity	Unit	Est. Unit Price

Description

Item No.	Acct., T.E., Sub. No., or W.O.	Deliver to Name	Location	Wanted by Date	Del. Schedule ☐Attached

Hazard Code(s): H___F___R___A___S___	BM Item No.	Property Item ☐Yes	Replacement Parts for

Noun	Vendor Part Number	Quantity	Unit	Est. Unit Price

Description

UCN-14715A (12-6 1-83))

SUBJECT: SUBCONTRACT SERVICES AND ADMINISTRATION

Exhibit 18.5. Requisition Change Request Form (UCN-14917).

REQUISITION CHANGE REQUEST FORM

NOTE: *Enter only data necessary to make requested changes.*
Enter original suggested vendor and item noun for all changes.

REASON:
☐ Revise Data ☐ Add Item(s)
☐ Cancel Req. ☐ Delete Item(s)

Requisition No.	Wanted by Date	Urgency	Urgency Approval Signature	Employee No.

INSPECTION	Special Inspection Name /Instructions	Code	HAZARDOUS No	Yes	U	Use Code	Hazard Employee No.
☐ Receiving ☐ Special							

Requester Signature	Requester Employee Number	Phone	Date

Installation Head or Authorized Representative Signature	Approval Employee Number	Date

REFER TECHNICAL QUESTIONS TO: *(If different from requester)* Name	Phone	BM Number	Priority	DOD Program	Commodity Code

SUGGESTED VENDOR(S)

ATTACHMENT(S) INDICATOR(S):
☐ 1. Classified ☐ 3. Specifications ☐ 5. Samples ☐ 7. Del. Sch.
☐ 2. Drawings ☐ 4. Sole Source ☐ 6. Controlled Subst. ☐ 8. Other

Requester Identification/Justification

Remarks to Purchasing

Item No.	Account, T.E., Sub. No., or W.O.	Deliver to Name	Location	Wanted by Date	Del. Schedule ☐ Attached

Hazard Code(s): H__ F__ R__ A__ S__	BM Item No.	Property Item ☐ Yes	Replacement Parts for

Noun	Vendor Part Number	Quantity	Unit	Est. Unit Price

Description

Item No.	Account, T.E., Sub. No., or W.O.	Deliver to Name	Location	Wanted by Date	Del. Schedule ☐ Attached

Hazard Code(s): H__ F__ R__ A__ S__	BM Item No.	Property Item ☐ Yes	Replacement Parts for

Noun	Vendor Part Number	Quantity	Unit	Est. Unit Price

Description

UCN-14917 (126 10-83)

Exhibit 18.6. Example for services.

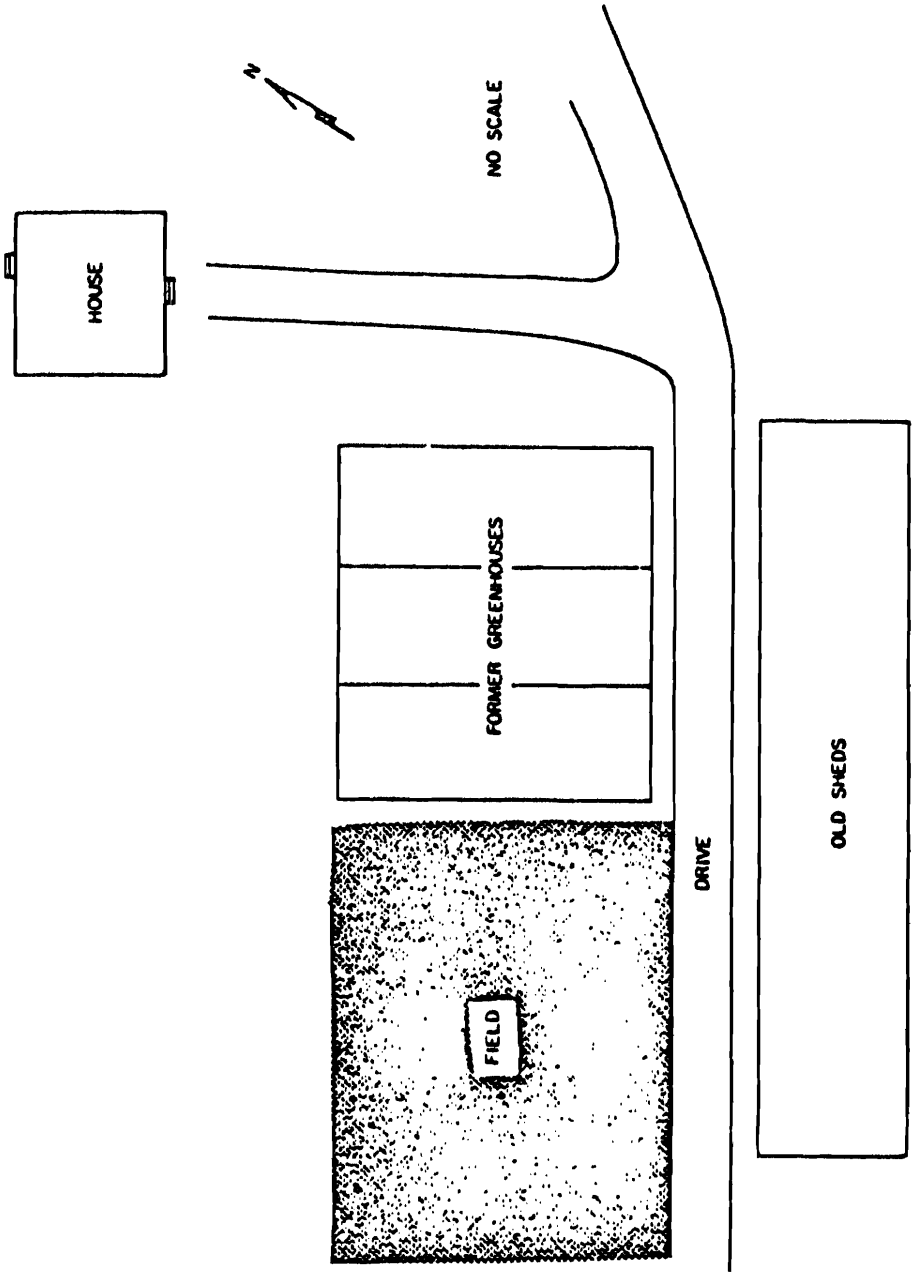


Fig. 2. Approximate location and areal extent of field requiring services. (Area indicated by shading.)

SUBJECT: SUBCONTRACT SERVICES AND ADMINISTRATION

Exhibit 18.6. (Continued)

19. QA PROCEDURES

19. QA PROCEDURES

19.1 INTERFACE CONTROL

19.1.1 Purpose

The purpose of this procedure is to describe the various types of organizational interfaces that occur during the activities conducted through the ORNL-RASA program.

19.1.2 Applicability

This procedure applies to those activities that form a part of the ORNL-RASA program. The intent of this procedure is to list those organizations with whom contact is made and to describe restrictions on interface, by position. Interface between procedures and sections of the ORNL-RASA Procedures Manual is discussed in Sect. 1.4, QA Policy Manual and, therefore, does not apply to this procedure.

19.1.3 References

1. Sect. 1.4, QA Policy Manual
2. Sect. 2.3, ORNL-RASA Administrative Organization
3. Sect. 15, Laboratory Analyses
4. Sect. 18, Subcontract Services and Administration
5. Sect. 20, Measuring and Test Equipment Calibration

19.1.4 Definitions and Abbreviations

PROJECT MANAGER. An individual appointed by the ORNL-RASA program manager to coordinate the activities of a subcontractor performing special services for the ORNL-RASA program that are not site related.

Also see Sect. 1.5 of this manual, Terminology.

19.1.5 Responsibilities

The ORNL-RASA program manager is responsible for ensuring that all interfaces with outside organizations are performed by designated personnel in accordance with established procedures.

19.1.6 Procedure

19.1.6.1 DOE

Interface with the Oak Ridge Operations Office of the DOE will be performed only by the ORNL-RASA program manager and those personnel specifically designated by him. This activity may consist of the following, as applicable:

1. Receipt of candidate site information
2. Scheduling
3. Development of survey scope
4. Submittal of preliminary and completed survey plans and reports
5. Other discussions as necessary

19.1.6.2 ORNL Purchasing

The ORNL-RASA program manager or his designee will have the responsibility of interfacing with ORNL Purchasing as described in Sect. 18, Subcontract Services and Administration.

19.1.6.3 Subcontractors

Once contractual obligations are established, interface between the site leader or other designated representative and the subcontractor may consist of scheduling and ensuring final submittal of required data and/or reports as well as ensuring that services are performed as requested.

19.1.6.4 Plant and Equipment Division

The ORNL-RASA program manager or his designated representative may initiate maintenance of equipment and will be responsible for interfacing with responsible personnel in the Plant and Equipment Division.

19.1.6.5 EOSD Calibration Laboratory

The interfaces between ORNL-RASA personnel and EOSD Calibration Laboratory are described in Sect. 20, Measuring and Test Equipment Calibration.

19.1.6.6 Analytical Chemistry Division

The site leader or laboratory technologist will be responsible for interfacing with Analytical Chemistry Division for submittal of samples collected from survey sites and obtaining results of analyses as applicable in accordance with Sect. 15, Laboratory Analyses. Requirements for sample analysis techniques to be employed can be identified only by the ORNL-RASA program manager or his designee.

19.1.6.7 Martin Marietta Energy Systems Auditing

The interface between ORNL-RASA personnel and the Martin Marietta Energy Systems Auditing group is limited to supplying any relative information that may be requested, such as the past performance of particular subcontractors, and will be the responsibility of the applicable project manager (for services other than site related) or site leader (for site-related services).

19.1.6.8 HASRD

All interface with HASRD is administrative in nature and will be accomplished through the RASA group leader as described in Sect. 2.3, ORNL-RASA Administrative Organization.

19.1.6.9 Dosimetry and Biophysical Transport Section

In all administrative matters the ORNL-RASA program reverts to the RASA group of the Dosimetry and Biophysical Transport Section, which in turn is a section of HASRD. Therefore, all interfacing with Dosimetry and Biophysical Transport Section is performed through the ORNL-RASA leader as described in Sect. 2.3, ORNL-RASA Administrative Organization.

19.1.6.10 EOSD

The site leader and instrument technologist will ensure, through interfacing with EOSD, that transfer of equipment and material is accomplished through contamination checks and controls established by ORNL guidelines.

19.2 INDOCTRINATION, TRAINING, AND QUALIFICATION OF PERSONNEL

19.2.1 Purpose

The purpose of this procedure is to describe the indoctrination, training, and qualification requirements for ORNL-RASA program personnel.

19.2.2 Applicability

This procedure applies to all personnel performing tasks associated with the ORNL-RASA program. Special documented certification of personnel will not be made a part of this procedure as existing standards for qualification are maintained separately by the ORNL-RASA program manager.

19.2.3 References

1. Standard Practice Procedure D-3-1, "Employment"
2. "Performance Standards and Measures of Performance for the ORNL-RASA program manager"

19.2.4 Definitions and Abbreviations

19.2.4.1 Definitions

QUALIFICATIONS. The characteristics or abilities gained through training or experience, or both, that enable an individual to perform a specified function.

PERFORMANCE STANDARDS and MEASURES of PERFORMANCE. A document, maintained by the ORNL-RASA program manager that contains expected position responsibilities for members of the ORNL-RASA technical staff.

Also see Sect. 1.5 of this manual, Terminology.

19.2.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

19.2.5 Responsibilities

19.2.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager will be responsible for the following with respect to qualifications and training of personnel assigned to the ORNL-RASA program:

1. To establish job descriptions.
2. Ensure that the employment procedures defined in D-3-1 of the Martin Marietta Energy Systems Standard Practice Procedure are followed.
3. To maintain "Performance Standards and Measures of Performance."
4. To ensure that site leaders are designated based on experience and ability.
5. To ensure that all personnel within the ORNL-RASA program have become familiarized with those procedures that affect their assigned area.
6. To determine any specialized training requirements as necessary.

19.2.5.2 Site Leader

The site leader will be responsible for the following with respect to indoctrination and training of personnel selected to form a survey team:

1. To ensure that personnel are selected based on established experience in a given area.
2. To conduct an indoctrination of selected personnel in the technical objectives of the project, the standards to be used, and the quality assurance elements that are to be employed.
3. To ensure that those individuals selected for a survey team who have not demonstrated proficiency in a given area, such as equipment operation or sample identification, are properly trained in the basic requirements of the activity by authorized personnel (i.e. either the site leader or an individual with established experience in the given area).

19.2.5.3 QA Coordinator

The QA Coordinator will periodically evaluate the selection of personnel for survey teams to ensure that only properly qualified individuals have been selected or that appropriate indoctrination and training have been provided.

19.2.6 Procedure

The nature of this procedure is such that a sequential listing of specific actions is neither practical nor necessary.

19.3 PROCEDURE PREPARATION

19.3.1 Purpose

The purpose of this procedure is to establish the outline, format, and standard procedures to be used in preparing, revising, and deleting the procedures in the Radiological Survey Activities Procedures Manual.

19.3.2 Applicability

This procedure applies to all procedures prepared for the Radiological Survey Activities Procedures Manual. Sect. 1 (Introduction) and Sect. 2 (Integrated Activity Functional Description) of the manual contain background and descriptive information only and will be exempt from the format requirements of this procedure.

19.3.3 References

1. Sect. 19.8, Project Document Control

19.3.4 Definitions and Abbreviations

19.3.4.1 Definitions

REVIEWERS. Those individuals who have been assigned the responsibilities for administrative, QA, and operations activities.

Also see Sect. 1.5 of this manual, Terminology.

19.3.4.2 Abbreviations

PDN Procedure Deletion Notification

PRF Procedure Review Form

RPD Request for Procedure Deletion

19.3.5 Responsibilities

19.3.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for the review and approval of all procedures contained in the Radiological Survey Activities Procedures Manual. He is also responsible for the assignment of reviewers.

19.3.5.2 Reviewers

The reviewers review the procedures for proper integration of administrative, QA, and operational activities.

19.3.6 Procedure

19.3.6.1 Outline and Content

A procedure is normally prepared to respond to an administrative, QA, or operations requirement and to define how a particular activity is to be conducted. The outline for the content of Sects. 1 through 8 of each procedure (except Introduction and Integrated Activity Functional Description) will be the same for all procedures and will be the same as the outline used for this procedure. The content of each section of a procedure will be as follows:

Purpose

State the purpose or objective of the procedure. This statement will explain why the procedure is being written, as in Sect. 1 of this procedure.

Applicability

The application of the procedure will be stated in Sect. 2. The statement will clearly define the specific applicability and boundaries of the procedure and list any exceptions.

References

All documents referenced in the text of a procedure will be listed under Sect. 3. If no reference is used, place the word "None." under the heading.

Definitions and Abbreviations

Special definitions and abbreviations may be listed to clarify the terminology used in the procedure. When required, they will be included under their respective headings as shown in Sects. 4, 4.1 and 4.2 of this procedure. Following the entries include "Also see Sect. 1.5 of this manual, Terminology." If there are no definitions or abbreviations to list, include "See Sect. 1.5 of this manual, Terminology" under the heading.

Responsibilities

The title(s) of the individual(s) responsible for compliance with the procedure will be identified in Sect. 5.

Procedure

Subsection headings in Sect. 6 will reflect the specific subject matter being presented in the procedure. The subject matter will establish and detail the procedure steps required to implement the function or task to be performed in a manner that is fully responsive to applicable requirements, codes, and standards.

When making reference to other sections or procedures, the following standard format will be used, as applicable:

1. See Sect._____, step_____ of Sect._____, or
2. See Sect._____, step_____ of Sect._____, or
3. See Sect._____, step_____ of this procedure, or
4. See Sect._____ (when an entire section of the manual is to be referenced).

When making reference to exhibits, the standard format will consist of the exhibit title followed by the exhibit number in parentheses.

Exhibits

Tables, figures, attachments, and enclosures that are provided in the procedure will be placed immediately following the section.

19.3.6.2 Format

Procedure form

The procedure form will be the same as that used for this procedure.

Procedure number, revision, date, and page numbers

All procedures will be numbered per the guidelines established in the Procedure Numbering System (Exhibit 19.1).

The applicable procedure number, revision number, revision date, and page numbers will be entered in their respective spaces on each page.

Section headings

Section headings will be capitalized and underlined in accordance with the following scheme:

1. SECTION HEADING
1.1 SUBSECTION HEADING
1.1.1 Subsection Heading
1.1.1.1 Subsection Heading

Spacing

Draft versions may be double-spaced to facilitate review, mark-up, and commentary. Final drafts will be in 12-pitch type with no spaces between lines and one space between paragraphs.

Listed items

Items may be listed below any paragraph heading within the following limitations:

1. Items will be listed by a sequential number.
2. The second line of an item shall start directly under the first letter of the first line of each item.

Exhibits

All exhibits will be identified as Exhibit X.Y, where X is the section number and Y is the sequential exhibit number. Exhibits requiring more than one page will carry at the top of the page the notation "Exhibit_____ (continued)."

19.3.6.3 Procedure Preparation, Review, and Approval

Origination of new procedures

When a new procedure is required, a draft will be prepared using the standard format (see Sect. 6.2 of this procedure). In preparing the draft, the originator will ensure that all applicable requirements and current standards and guides have been incorporated as appropriate. An originator may be any member of the ORNL-RASA staff or personnel specified for this purpose by the ORNL-RASA program manager.

The originator will complete and sign Part 1 of the Procedure Review Form (Exhibit 19.2) and submit it and the procedure draft to the ORNL-RASA program manager. He and his reviewers will review the draft and will check for impact and conformance of the procedure with administrative, QA, and operations requirements.

If no significant errors are detected, the ORNL-RASA program manager will sign Part 2 of the Procedure Review Form (PRF) and return it and the draft to the originator.

If significant errors are detected during the above reviews, the draft and comments are returned to the originator for correction. Following correction the procedure starts the review cycle again using the original PRF.

When the draft is approved, the originator will submit the procedure for final typing and will submit the original, in its final form, to the ORNL-RASA program manager for approval. Distribution of the approved procedure will be as described in Sect. 19.11, Project Document Control.

The PRF and an associated procedure copy will be forwarded to the records technologist for retention in the history file.

Revision of existing procedures

When a procedure is to be revised, the originator will obtain a current copy and indicate the appropriate changes. After completing and signing Part 1 of the PRF, the originator will submit the marked up copy and the PRF to the same cycle as described in Sect. 6.3.1 of this procedure for review, approval, and distribution.

When a revised procedure is issued, the revised portion(s) will be identified by a vertical line in the right-hand margin. Previous revision marks, if any, will be removed.

Deletion of procedure

When a procedure is to be deleted, a Request for Procedure Deletion (RPD) (Exhibit 19.3) will be initiated and forwarded to the ORNL/RASA program manager. If the manager and his reviewers concur, the procedure will be deleted. If objections are raised, the procedure remains valid until sufficient justification for deletion is presented and approved by the ORNL-RASA program manager.

Once a procedure has been deleted, a Procedure Deletion Notification (PDN) (Exhibit 19.4) will be completed by the ORNL-RASA program manager and distributed to all holders of controlled copies of the Procedures Manual, with instructions to discard the subject procedure in their possession.

The originals of the RPD and the PDN will be forwarded to the records technologist for retention in the procedure master file.

19.4 CONTROL OF PURCHASED ITEMS AND SERVICES

19.4.1 Purpose

The purpose of this procedure is to describe the internal ORNL-RASA controls to ensure that purchased items and services conform to procurement documents.

19.4.2 Applicability

This procedure applies to items and services required to implement activities associated with the ORNL-RASA program. Because items and services must be purchased through the Procurement Division of Martin Marietta Energy Systems, the ORNL Standard Practices and Guidelines apply.

19.4.3 References

1. Sect. 2.3, ORNL-RASA Administrative Organization
2. Sect. 11.3, Identification of Subcontractor Requirements
3. Sect. 18.1, Procurement of Services and Equipment
4. ORNL/CF-79/53 Guidelines for Subcontracting at ORNL
5. D-2-16 Standard Practice Procedure Martin Marietta Energy Systems, Quality Assurance Program
6. D-2-16S ORNL Supplement, Standard Practice Procedure Martin Marietta Energy Systems, Quality Assurance Program
7. D-2-8 Standard Practice Procedure Martin Marietta Energy Systems, Consultant and Special Services
8. D-2-8S ORNL Supplement Standard Practice Procedure Martin Marietta Energy Systems, Consultant and Special Services
9. D-2-1 Standard Practice Procedure, Part 1, Procurement of Material
10. Martin Marietta Energy Systems Procurement Division Manual

19.4.4 Definitions and Abbreviations

19.4.4.1 Definitions

PROCUREMENT DOCUMENT. Purchase requisitions, purchase orders, drawings, contracts, specifications, or instructions used to define requirements for purchase.

Also see Sect. 1.5 of this manual, Terminology.

19.4.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

19.4.5 Responsibilities

19.4.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for ensuring that all items and services are procured according to the guidelines and standards established in the reference section of this procedure. He is also responsible for approving requests for the procurement of all items and services.

19.4.5.2 QA Coordinator

The QA coordinator is responsible for reviewing requests for procurement of items and services to ensure that applicable quality requirements are included or referenced in procurement documents.

19.4.5.3 Technical Staff Member

The technical staff member assigned to a particular project is responsible for identifying the requirements for purchased items and services, preparing requests for purchase, obtaining necessary approvals from the ORNL-RASA program manager, and ensuring the acceptability of items and services received in accordance with procurement documents for his project.

19.4.6 Procedure

19.4.6.1 Martin Marietta Energy Systems Quality Assurance Program

The Martin Marietta Energy Systems Quality Assurance Program is described in Standard Practice Procedures D-2-16 and D-2-16S, which include provisions for the control of procurement documents and purchased items and services. The requirements contained in the Martin Marietta Energy Systems QA Program will ensure that proposals are properly reviewed, minimum QA Program criteria are imposed on suppliers and subcontractors, and that suppliers of items and services are properly qualified.

19.4.6.2 Evaluation of Conformance to Procurement Documents (RASA Surveys)

Where site survey work requires purchased items and services, the site leader will remain cognizant of the requirements established in procurement documents. Any deviation or departure from these requirements will be reported to the ORNL-RASA program manager for determination of further action in accordance with internal Martin Marietta Energy Systems guidelines. The QA coordinator may assist the ORNL-RASA program manager in this determination.

19.4.6.3 Evaluation of Conformance to Procurement Documents (Technical R&D Contracts)

Evaluation of conformance to the requirements established for technical R&D contracts associated with the ORNL-RASA program are normally delegated by the ORNL-RASA program manager to a project manager who will remain cognizant of the contract requirements. Any deviation or departure from established requirements by the subcontractor will be reported to the ORNL-RASA program manager for determination of further action in accordance with internal Martin Marietta Energy Systems guidelines. The QA coordinator may assist the ORNL-RASA program manager in this determination.

19.5 IDENTIFICATION AND CONTROL OF MATERIAL AND EQUIPMENT

19.5.1 Purpose

The purpose of this procedure is to describe the requirements for ensuring the proper identification and control of material and equipment used in the ORNL-RASA program.

19.5.2 Applicability

This procedure applies to equipment, instrumentation and supplies such as detectors, computers, peripherals, analyzer components and their support systems, measuring and test calibration or comparison, and prototype instrumentation and equipment that are assigned unique I&C control numbers. Associated electronic tools and supplies are maintained on an ORNL-RASA inventory.

Identification of samples, technical data, and reports is described in other procedures.

19.5.3 References

1. Sect. 16, Equipment Inventory Control and Maintenance
2. Sect. 20, Measuring and Test Equipment Calibration

19.5.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

19.5.5 Responsibilities

19.5.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for ensuring that adequate equipment and supplies are available for implementation of the ORNL-RASA program.

19.5.5.2 Site Leader

The site leader is responsible for ensuring that only equipment and supplies authorized for use on the ORNL-RASA program are used in the performance of radiological surveys and associated Laboratory activities.

19.5.5.3 QA Coordinator

The QA coordinator is responsible for ensuring that equipment and supplies are properly utilized in accordance with this and referenced procedures.

19.5.6 Procedure

19.5.6.1 Equipment Identification

Identification of equipment is accomplished internally within Martin Marietta Energy Systems and is dependent upon accountability and inventory controls established by the applicable Martin Marietta Energy Systems department. Equipment received for use by ORNL-RASA will carry the same identification as assigned by the responsible Martin Marietta Energy Systems department to provide for accurate traceability to applicable records.

19.5.6.2 Equipment Inventory

Accountability of equipment assigned to the ORNL-RASA program will be accomplished through the use of logs and inventory records identifying the location of the equipment.

19.5.6.3 Radioactive Sources

Identification of radioactive sources will be as described in appropriate calibration procedures identified in Sect. 20 of this manual, Measuring and Test Equipment Calibration.

19.5.6.4 Supplies

Supplies used for radiological surveys need not be specifically identified or authorized for use on the ORNL-RASA program.

19.5.6.5 Use of Unauthorized Equipment

Improperly identified or unidentified equipment, instrumentation and/or radioactive sources should not be used during the performance of activities associated with the ORNL-RASA program (see Sect. 16, Equipment Inventory Control and Maintenance, for identification requirements). Any deviation or departure from this requirement will be reported to the ORNL-RASA program manager for determination of appropriate action.

19.6 INSPECTION, TEST AND OPERATING STATUS

19.6.1 Purpose

The purpose of this procedure is to provide requirements for the checking of equipment status and providing an overview of the documentation of activities associated with site surveys.

19.6.2 Applicability

This procedure applies to all ORNL-RASA radiological survey activities.

19.6.3 References

None.

19.6.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

19.6.5 Responsibilities

19.6.5.1 Site Leader

The site leader is responsible for accumulating all information relative to his assigned site(s) and periodically reporting the status of site activity to the ORNL-RASA program manager. He is also responsible for the accuracy and completeness of all information recorded in appropriate logs and other data used to provide status of completed activities.

19.6.5.2 QA Coordinator

The QA Coordinator is responsible for periodically reviewing the status of site surveys to evaluate whether or not records and logs are adequately prepared and contain sufficient information to provide actual status of survey activity. He is responsible for reporting to the ORNL/RASA program manager any discrepancy with respect to the continuous recordkeeping of site survey activities.

19.6.5.3 Instrument Technologist

The instrument technologist is responsible for checking the condition and operability of equipment used during site survey activities.

19.6.6 Procedures

19.6.6.1 Equipment Status

Prior to each use, the instrument technologist will inspect the condition of equipment to be used during a site survey activity. This inspection will include verification that equipment has been calibrated and the due date for recalibration has not passed. After the inspection he will record any indications of damage, wear, or malfunction and calibration date status in the appropriate equipment log book.

19.6.6.2 Status Reporting

Before the end of each week, the site leader will prepare and submit input to the ORNL-RASA program manager relative to the status of completed and anticipated site survey activities. This information should contain, as a minimum:

1. Identification of those portions of major sites and/or vicinity properties that have been surveyed since the last reporting period.
2. A description or accounting of the reports prepared and issued during the reporting period.
3. Statements regarding the continuing nature of laboratory analyses.
4. A schedule of activities planned during the subsequent reporting period.
5. A description of unusual or unexpected problems encountered during the performance of survey activities such as problems with subcontractors, the need for special equipment or modifications to existing equipment, etc.

19.7 SAMPLE COLLECTION, CONTROL, AND DOCUMENTATION

19.7.1 Purpose

The purpose of this procedure is to establish methods and general criteria to ensure that samples obtained from ORNL-RASA survey sites are obtained in the specified manner, that the radiological characteristics of these samples are not altered before they are analyzed as a result of handling practices or storage environment, and that samples are properly identified and analyzed with documented results.

19.7.2 Applicability

This procedure applies to all sample collection, analysis, and documentation performed as part of the ORNL-RASA program.

19.7.3 References

1. Sect. 14, Sample Collection
2. Sect. 15, Laboratory Analysis
3. Sect. 19.1, Interface Control
4. Sect. 19.12, Calibrations and Intercomparison Data
5. USNRC Reg. Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment (for guidance only)

19.7.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

19.7.5 Responsibilities

19.7.5.1 Site Leader

The site leader is responsible for ensuring that all collection, identification, handling, shipping, analysis, and documentation of samples is

performed by appropriately qualified personnel in accordance with established and approved procedures. He is also responsible for ensuring, through delegated responsibilities, that interface organizations (see Sect. 19.1, Interface Control) performing services related to the above elements are providing those services in accordance with good practices sufficient to ensure the integrity and quality of sample results.

19.7.5.2 QA Coordinator

The QA Coordinator is responsible for periodically reviewing the sample collection practices and the data generated as a result of sample analysis for determination of adherence to established practices and procedures.

19.7.6 Procedure

19.7.6.1 Sample Collection

Sample collection performed during radiological surveys will be performed in accordance with Sect. 14, Sample Collection. All samples collected at survey sites will be identified with a unique identification code for traceability in accordance with the procedure of Sect. 14.8, Sample Identification and Labeling.

19.7.6.2 Shipping, Handling, and Receiving

All samples will be packaged, shipped, and received in accordance with the procedure of Sect. 14.6, Packaging and Shipment of Environmental Samples, to maintain the integrity and traceability of the sample from time of collection to time of analysis.

19.7.6.3 Sample Analysis

All sample analyses performed as part of the ORNL-RASA radiological surveys will be performed in accordance with Sect. 15, Laboratory Analyses.

19.7.6.4 Review of Analyses

All analysis results of samples collected from RASA survey sites will be reviewed by the site leader or his designee for comparison with other related measurement results for that site.

19.7.6.5 Computational Checks

As determined by the QA coordinator, a review of the analyses involved in computation of the concentration of radioactive materials in the samples may include an independent verification of the results of the computation by persons not having direct responsibility for the original computation.

19.7.6.6 Cross-Checks and Inter-Laboratory Analyses

To provide independent tests of the ability to measure radionuclides in the very low concentrations present in most environmental samples, the QA coordinator may determine the need to institute a laboratory intercomparison studies program in accordance with the procedure of Sect. 19.9, Calibrations and Intercomparison Data. Samples may be intentionally left blank or spiked with known concentrations to provide a more efficient means of cross-check.

19.7.6.7 Sample Retention Periods and Storage

Sample storage at the Laboratory after analysis is complete will be performed in accordance with the procedure of Sect. 14.9, Storage of Environmental Samples. Samples will remain archived until the ORNL-RASA program manager orders sample retrieval or until DOE issues instructions to discard the samples. Documentation of sample storage locations is maintained by the records technologist according to the procedure of Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples.

19.8 PROJECT DOCUMENT CONTROL

19.8.1 Purpose

The purpose of this procedure is to describe measures to control the issuance and revision of documents, such as instructions, procedures, and drawings, that describe activities affecting the RASA program.

19.8.2 Applicability

This procedure applies to input data, forms, procedures, equipment operating and maintenance manuals, and final issued documents used during the various stages of RASA radiological surveys.

19.8.3 References

1. Sect. 4, Preliminary Survey Planning
2. Sect. 5, Vicinity Properties Survey Planning
3. Sect. 6, Candidate Site Survey Planning
4. Sect. 7, Postremedial Action Survey Planning
5. Sect. 10.5, Reports and Papers
6. Sect. 11.1, Evaluation of Site Records and Data
7. Sect. 19.11, Maintenance and Control of Records and Data

19.8.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

19.8.5 Responsibilities

19.8.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for approving all ORNL-RASA issued documents in accordance with the procedure of Sect. 10.5, Reports and Papers.

19.8.5.2 Site Leader

The site leader is responsible for organizing and reviewing the input data necessary for establishing the basis of site survey planning in accordance with Sects. 4, 5, 6, and 7 of this manual. He is also responsible for ensuring the availability of ORNL-RASA procedures and forms to personnel performing site survey activities.

19.8.5.3 QA Coordinator

The QA Coordinator is responsible for the maintenance and control of project records and data in accordance with the procedure of Sect. 19.11, Maintenace and Control of Records and Data. He is also responsible for maintaining a system of controlled issuance of the ORNL-RASA Procedures Manual to ensure that outdated revisions of procedures are not in use.

19.8.5.4 Records Technologist

The records technologist is responsible for assisting the QA Coordinator in his responsibilities.

19.8.6 Procedure

19.8.6.1 General

To the extent possible, all records, data, maintenance manuals, and forms used or referenced in site survey related activities will be identifiable by revision level and date.

19.8.6.2 Survey Planning

In the process of survey planning, the site leader will verify that input data and records used are the latest available sources of information. He may elect to compare this data with historical site information to determine physical changes. These sources consist of Preliminary Site Radiological Survey Reports, site usage history, site geographical and topographical information, facility drawings and photographs, plat maps, and aerial survey results.

In reviewing completed site survey plans, the QA Coordinator will compare the references described in such plans with information available in the ORNL-RASA files to determine correct usage of the latest project documents.

19.8.6.3 ORNL-RASA Procedures Manual

Distribution of the ORNL-RASA Procedures Manual will be accomplished by cover letter to assigned individuals who will be accountable for the assigned manual. Manuals are to be distributed in total to ensure that personnel using specific procedures also have available those procedures or sections that may be referenced.

To accommodate the usage of procedures during field activities, a manual may be assigned to a mobile van. However, an individual assigned by the ORNL-RASA program manager will be designated accountable for the manual.

The QA Coordinator will ensure that the records technologist receives a file copy of all cover letters used to issue ORNL-RASA Procedures Manuals. When procedures are revised and approved for issue, they will be distributed to all manual holders. The cover letter will contain instructions concerning the disposition of obsolete procedures or sections. A file copy of all revisions of ORNL-RASA Procedures Manual sections and procedures will be retained by the records technologist to provide a historical record of revisions in accordance with the procedure of Sect. 19.3, Procedure Preparation.

19.8.6.4 Equipment, Operating and Maintenance Manuals

Equipment operating and maintenance manuals will accompany the associated equipment at all times. As a precaution, a copy of these manuals will also be maintained in the corresponding records files. Where this is not practicable, sufficient data will be recorded to ensure the ability to reorder appropriate information in the event a manual is misplaced or lost.

When changes to operating parameters or maintenance procedures are made for a piece of equipment, changes to the corresponding equipment operating and maintenance manuals will be made. These changes will be identified by revision level and date as in Sect. 6.1 of this procedure.

19.8.6.5 Data Collection and Reporting Forms

The use of up-to-date forms and report formats will be controlled through periodic surveillances of this activity. The records technologist will maintain a separate file of all forms used to report RASA activities and ensure that when forms are revised, all outdated copies are removed from use or destroyed.

19.9 CALIBRATIONS AND INTERCOMPARISON DATA

19.9.1 Purpose

The purpose of this procedure is to provide a method by which quality of equipment and instrument calibration is ensured through the use of intercomparison analyses.

19.9.2 Applicability

This procedure applies to the analysis of quality control samples and measurements to determine the precision and accuracy of equipment and instrument calibration. This procedure also provides an interface with the calibration program to ensure that corrective action is taken when anomalies are discovered.

19.9.3 References

1. Sect. 16.3, Equipment Calibration Records
2. Sect. 19.7, Sample Collection, Control, and Documentation
3. Sect. 20, Measuring and Test Equipment Calibration
4. USNRC Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment. (For guidance only.)
5. EPA-600/4-77-001, January 1977, Environmental Radioactivity Laboratory Intercomparison Studies Program. (For guidance only.)

19.9.4 Definitions and Abbreviations

19.9.4.1 Definitions

QUALITY CONTROL SAMPLE. Replicate samples (containing significant detectable activity), samples containing known concentrations of radionuclides, laboratory blanks, and analytical blanks.

Also see Sect. 1.5 of this manual, Terminology.

19.9.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

19.9.5 Responsibilities

19.9.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for the establishment of a program to ensure that all equipment used to perform measurement, test, and analysis in the performance of ORNL-RASA activities is properly calibrated. See Sect. 20, Measuring and Test Equipment Calibration.

19.9.5.2 QA Coordinator

The QA Coordinator is responsible for periodically determining the need for implementation of a Laboratory intercomparison analysis system; upon implementation he will evaluate the results and initiate corrective action where anomalies are discovered. He is also responsible for ensuring that adequate records of equipment calibration are maintained in accordance with Sect. 20 of this manual, Measuring and Test Equipment Calibration.

19.9.6 Procedure

19.9.6.1 Laboratory Intercomparison Studies Programs

ORNL-RASA has not yet instituted an intercomparison analysis system identifying the types of samples and measurements and frequency that samples are exchanged for comparison data. When this system is developed, the programs established by the Environmental Protection Agency (for samples) and the Environmental Measurements Laboratory (EML)/Nuclear Regulatory Commission (for measurements) will be used as a guide.

The QA coordinator will ensure that corrective action is established and documented in the appropriate calibrated instrument files, concerning any deficiencies noted as a result of the intercomparison analysis system. This corrective action will include the identification of the tests performed prior to discovery of the deficiency for determination of further corrective action.

19.10 CONTROL OF DEFICIENT ITEMS

19.10.1 Purpose

The purpose of this procedure is to describe the methods for identifying and segregating deficient items and obtaining corrective action.

19.10.2 Applicability

This procedure applies to equipment and instrumentation improperly identified, in disrepair, or in need of calibration.

19.10.3 References

1. Sect. 18.1, Procurement of Services and Equipment
2. Sect. 19.3, Procedure Preparation
3. Sect. 19.4, Control of Purchased Items and Services
4. Sect. 20, Measuring and Test Equipment Calibration

19.10.4 Definitions and Abbreviations

19.10.4.1 Definitions

DEFICIENCY. A nonconformance or departure of a characteristic from specified requirements. For purposes of this procedure, deficiencies are limited to equipment and instrumentation that may be damaged, in need of modification, improperly identified, or past the due date for calibration such that the quality of associated tests, analyses, or measurements would be in question.

19.10.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

19.10.5 Responsibilities

19.10.5.1 QA Coordinator

The QA Coordinator is responsible for performing follow-up of identified deficiencies to obtain corrective action.

19.10.5.2 Site Leader

The site leader is responsible for ensuring the early detection of deficiencies in all equipment and instrumentation utilized in the performance of radiological surveys. He is also responsible for instructing all survey team members in the use of this procedure.

19.10.5.3 Instrument Technologist

The instrument technologist is responsible for maintaining appropriate documentation demonstrating the status of identified deficiencies. He is also responsible for informing the Calibration Records Technologist of equipment or instrumentation identified as deficient and in need of calibration in accordance with Sect. 20, Measuring and Test Equipment Calibration.

19.10.6 Procedure

19.10.6.1 Identification of Deficiencies

Deficiencies in equipment and instrumentation may be identified by any member of the ORNL-RASA staff. Once a deficiency is identified and a description of the deficiency is noted in the appropriate log book, the site leader will be informed so that he may make a determination of whether or not continued use of the equipment or instrumentation is justified.

19.10.6.2 Temporary Disposition of Deficiency

If it cannot be immediately determined that a deficiency will cause the quality of associated tests, analyses, or measurements to be in question, the site leader may elect to allow the continued use of the equipment or instrumentation. However, after repair or calibration, an evaluation should be made to determine if any retesting must be performed.

19.10.6.3 Repair or Modification of Damaged Equipment and Instrumentation

The site leader or instrument technologist will determine the test method of repair. The available alternatives are to perform the work in-house by sending the item to the ORNL I&C Laboratory or through use of an outside repair service. If outside repair services are elected, the requirements of the procedures of Sects. 18.1, Procurement of Services and Equipment, and 19.4, Control of Purchased Items and Services, will apply. If repair of the item involves modification of the equipment or instrumentation, an evaluation should be made to determine whether or not any changes to instructions contained in applicable procedures are necessary. See Sect. 19.3, Procedure Preparation, for guidance on procedure changes.

19.10.6.4 Lack of Identification

If equipment or instrumentation is not properly identified, the ORNL department responsible for its issue will be consulted to obtain the necessary information.

19.10.6.5 Deficiencies Suspected in Calibration

The requirements contained in applicable Sect. 20 procedures will be followed when equipment or instrumentation is suspected to be out-of-calibration or when the established due date for calibration has passed.

19.10.6.6 Records

Associated logs and records will be annotated with appropriate notations to describe the actions taken to correct deficiencies and to clear any questions concerning the validity of tests, analyses, and measurements. Records will be available for review by the QA coordinator to determine that deficiencies are properly identified and corrective action has been taken. If any adverse trends are noted during this review, a written report will be made by the QA coordinator to the ORNL-RASA program manager along with recommendations to prevent recurrence.

19.11 MAINTENANCE AND CONTROL OF RECORDS AND DATA

19.11.1 Purpose

The purpose of this procedure is to describe the QA requirements for indexing, filing, and maintenance of ORNL-RASA records and data.

19.11.2 Applicability

This procedure applies to records and data furnishing documentary evidence of ORNL-RASA activities.

19.11.3 References

1. Sect. 10.2, Project Recordkeeping
2. Sect. 10.5, Reports and Papers
3. Sect. 19.8, Project Document Control
4. ANSI N45.2.9-1979, Requirements for the Collection, Storage and Maintenance of Quality Assurance Records for Nuclear Power Plants (for guidance only).

19.11.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

19.11.5 Responsibilities

19.11.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for implementation of this procedure.

19.11.5.2 QA Coordinator

The QA Coordinator is responsible for periodically reviewing the condition of project records to ensure that records are (1) available when needed, (2) protected to prevent damage, and (3) transmitted to and filed in designated locations in a timely manner.

19.11.5.3 Records Technologist

The records technologist is responsible for records receipt, maintenance, retention, and retrieval.

19.11.6 Procedure

19.11.6.1 Records Administration

1. A records index will be maintained by the records technologist and used as a guide in the filing of documentation. Where records and data are physically maintained in separate locations, such as log books kept in mobile laboratories, the index should specify the location of these records to allow for retrievability.
2. Records and data will be authenticated, approved, and distributed, as applicable, in accordance with the procedure of Sects. 10.2, Project Recordkeeping; 10.5, Reports and Papers; and 19.8, Project Document Control and procedures referenced therein.
3. All records and data should be complete, having all entries filled out before being distributed to and accepted into the project file. Items should not be left blank; instead, the words "not applicable" or "NA" should be used.

4. All records and data should be identified by revision level and date to differentiate between records. Where this is not practical, the records index should provide sufficient information to distinguish between the record and the activity to which it applies.
5. Supplements or corrections to previously issued records and data will be identified as such and authenticated in the same manner as the original. Supplements will be filed with the original and corrections will be made on the original and initialed and dated by the individual making the correction.

19.11.6.2 Receipt

1. Records and data will be reviewed for completeness and filed in their designated locations.
2. The records technologist will resolve with the originator any questions concerning records and data to be filed.
3. Records and data will be filed in accordance with an index maintained in up-to-date status by the records technologist.

19.11.6.3 Storage, Preservation, and Safekeeping

1. Records and data maintained in the ORNL offices will be securely stored and protected from damage resulting from moisture and temperature. The ORNL Security System and Building Sprinkler System are relied on to provide support for records security and protection.
2. Records and data should be firmly attached in file folders or binders and filed in cabinets or on shelving in containers.
3. Only authorized personnel shall be allowed access to ORNL-RASA records and data.
4. Mobile laboratories will be kept locked when not in use to prevent unauthorized entry and provide security of data maintained inside.

19.11.6.4 Record and Data Disposition

Authorization will be obtained from the ORNL-RASA program manager prior to disposing of any records or data maintained in accordance with this procedure.

19.12 SURVEILLANCE PROGRAM

19.12.1 Purpose

The purpose of this procedure is to describe the requirements for surveillance and monitoring of ORNL-RASA activities to ensure continued implemen tation of quality requirements.

19.12.2 Applicability

This procedure applies to all ORNL-RASA activities performed at survey sites and at ORNL.

19.12.3 References

1. Sect. 1.3, Scope
2. Sect. 19.10, Control of Deficient Items

19.12.4 Definitions and Abbreviations

See Sect. 1.5 of this manual, Terminology.

19.12.5 Responsibilities

19.12.5.1 ORNL-RASA Program Manager

The ORNL-RASA program manager is responsible for conveying to all members of the ORNL-RASA program the importance of continued surveillance and monitoring of activities to ensure that applicable procedures are followed and requirements are implemented in accordance with Sect. 1.3 of this manual, Scope.

19.12.5.2 QA Coordinator

The QA Coordinator is responsible for (1) evaluating compliance to established procedures, (2) informing the ORNL-RASA program manager of the results of the evaluation, and (3) making recommendations for correcting adverse trends.

19.12.5.3 Site Leader

The site leader is responsible for continuous surveillance and monitoring of site-survey-related activities to ensure that procedures are being adequately observed and followed.

19.12.6 Procedure

NOTE: Currently, ORNL-RASA has not implemented a formal surveillance program that would involve the use of specific checklists or the formalization of schedules or reports. As the program is further developed, these mechanisms will be considered for implementation.

19.12.6.1 Procedure Compliance

All members of ORNL-RASA are required to comply with the sections and procedures that form the ORNL-RASA Procedures Manual. Noncompliance with procedure requirements may be determined by the site leader through continuous monitoring of activities.

19.12.6.2 Reporting

If a quality deficient situation is detected, such as the failure to observe an established procedure, lack of an established procedure describing an activity being performed, or failure to adequately identify items, etc., the ORNL-RASA program manager will be informed. Deficiencies related to equipment and instrumentation are discussed in the procedure of Sect. 19.10 of this manual, Control of Deficient Items.

19.12.6.3 Evaluation

1. Upon identification of a situation such as described in Sect. 6.2 of this procedure, the consequences of the noncompliance will be evaluated by the ORNL-RASA program manager and QA Coordinator. Corrective actions taken should be adequately documented. This may involve retraining of individuals, changing of applicable procedures, or development of new procedures.
2. The QA coordinator will be aware of all situations detected in accordance with this procedure to identify any adverse trends requiring more detailed evaluation and corrective action.

Exhibit 19.1. Procedure numbering system*

Section no.	Section and procedures description
	Introduction Section
1	INTRODUCTION
	Integrated Activity Functional Description Section
2	INTEGRATED ACTIVITY FUNCTIONAL DESCRIPTION
	Planning Procedures Sections
3	PROGRAM ADMINISTRATION
4	PRELIMINARY SURVEY PLANNING
5	VICINITY PROPERTIES SURVEY PLANNING
6	CANDIDATE SITE SURVEY PLANNING
7	POSTREMEDIAL ACTION SURVEY PLANNING
8	SUPPORT FUNCTION PLANNING
9	QA PLANNING
	Implementing Procedures Sections
10	PROJECT MANAGEMENT
11	PRE-SURVEY ACTIVITIES
12	MOBILE GAMMA SCANNING VAN
13	FIELD MEASUREMENTS
14	SAMPLE COLLECTION
15	LABORATORY ANALYSES
16	EQUIPMENT INVENTORY CONTROL AND MAINTENANCE

Exhibit 19.1. (Continued).

Section no.	Section and procedures description
17	MONITORING AND DECONTAMINATION
18	SUBCONTRACT SERVICES AND ADMINISTRATION
19	QA PROCEDURES
20	MEASURING AND TEST EQUIPMENT CALIBRATION
21	COMPUTER OPERATION
	ATTACHMENTS

*Procedures are to be numbered according to the 21 sections of the Procedures Manual.

Exhibit 19.2. Procedure review form (PRF).

PART 1 ( ) NEW ( ) REVISED

Procedure Number:_____Revision:_____

Title:_____

Page(s) and Paragraph(s) Affected:

Reason and References

Originator:_____ Date:_____

PART 2

Approval:

ORNL-RASA Program Manager:_____Date:_____

SUBJECT: QA PROCEDURES

Exhibit 19.3. Request for procedure deletion (RPD).

Procedure Number:_____ Revision:_____

Title:_____

It is requested that the above procedure be deleted. Reason for deletion:

Originator:_____ Date:_____

Comments:

Concurrence:

ORNL-RASA Program Manager:_____

Date:_____

Exhibit 19.4. Procedure deletion notification (PDN).

Procedure Number:_____ Revision:_____

Title:_____

The above procedure has been deleted from the Radiological Survey Activities Procedures Manual.

Discard the copy of the procedure in your possession and replace it with this sheet.

ORNL-RASA Program Manager:_____

Date:_____

20. MEASURING AND TEST EQUIPMENT CALIBRATION

20. MEASURING AND TEST EQUIPMENT CALIBRATION

20.1 CALIBRATION OF ALPHA SCINTILLATORS

20.1.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration and field check of portable alpha scintillation detectors.

20.1.2 Applicability

This procedure applies to all standard portable alpha scintillation detectors used in the ORNL-RASA program.

20.1.3 References

1. Sect. 13.2, Alpha Radiation Measurements
2. Sect. 16.3, Equipment Calibration Records
3. Eberline PRM-4 Count Rate Meter Technical Manual
4. Technical Associates Alpha Survey Meter Model Q-2789-1, Technical Manual
5. Technical Associates ORNL type "Beer Mug" Probe Model Q-2101, Technical Manual
6. Eberline "RASCAL" Ratemeter Technical Manual
7. Eberline AC-3 Scintillator Technical Manual
8. ANSI N323-1978 Radiation Protection Instrumentation Test and Calibration (for guidance only)

20.1.4 Definitions and Abbreviations

20.1.4.1 Definitions

LOG BOOK. At the ORNL-RASA Laboratory, the Instrument Calibration Log Book will be used for all laboratory calibration. At a survey site, the Portable Instrument Log Book will be used for all calibration related field activities.

CALIBRATED INSTRUMENT FILE. Calibration Records external to the log book maintained at the ORNL-RASA laboratory by the records technologist.

Also see Sect. 1.5 of this manual, Terminology.

20.1.4.2 Abbreviations

cpm Counts per minute

dpc Disintegrations per count

ANSI American National Standards Institute

EOSD Environmental and Occupational Safety Division

Also see Sect. 1.5 of this manual, Terminology

20.1.5 Responsibilities

The instrument technologist is responsible for implementing this procedure, and the records technologist is responsible for maintaining retrievable calibration data and records as supplied by the instrument technologist.

20.1.6 Procedures

20.1.6.1 Equipment and Supplies

1. Eberline PRM-4 Count Ratemeter, modified with ORNL digital counter and attached to an Eberline AC-3 Scintillation Probe
2. Technical Associates Q-2789-1 Survey Meter attached to an ORNL type "Beer Mug" Model Q-2101 Probe
3. Eberline "RASCAL" Ratemeter attached to an Eberline AC-3 Scintillation Probe

20.1.6.2 Radiation Sources

Eberline NBS traceable sources or their equivalent.

1. #10945, ^{230}Th, 9710 dpm, calibration date: 7-17-78
2. #10944, ^{230}Th, 3940 dpm, calibration date: 7-17-78
3. #10941, ^{230}Th, 1170 dpm, calibration date: 7-17-78

20.1.6.3 Calibration Frequency

Primary laboratory calibration will be performed at least quarterly and immediately following any maintenance or repair of the instrument. A field check will be performed at least daily during use.

20.1.6.4 Applicable Standards

ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration, is the applicable standard for this procedure (for guidance only).

20.1.6.5 Calibration Procedure

Laboratory calibration

1. Notify ORNL EOSD that the instrument is to be sent out for calibration and that a radiological survey and clearance for shipment of the instrument is required.
2. Following the radiological survey, EOSD personnel will place a "green tag" (contamination tag, ORNL Form Number UCN-14) on the instrument approving it for shipment to ORNL EOSD Standards Laboratory. If radioactive contamination exists, decontamination of the instrument by RASA personnel is required.
3. Send instrument to ORNL EOSD Standards Laboratory for calibration.
4. Following calibration and receipt of the instrument, verify the instrument identification and probe numbers and that EOSD Standards Laboratory has affixed a calibration tag to the instrument.
5. Notify the records technologist that the instrument has been calibrated. Supply the records technologist with the instrument number, date of calibration, and the EOSD Standards Laboratory Calibration Value (DPC).

Field check

1. Check batteries.

   For Eberline PRM-4, check battery condition by setting "ON-OFF BATT" switch in "BATT" position and observing the PRM-4 meter. If needle indicator does not fall within the "battery" range on the dial, battery replacement is mandatory (see Eberline Technical Manual for PRM-4 Count Ratemeter).

   For Technical Associates Q-2789-1 Survey Meter, batteries should be charged every 48 h during use. Recharge is indicated only by low count rates during daily field check.

   For Eberline "RASCAL" Ratemeter, check battery condition by turning instrument on and observing the "BAT OK" display on the instrument display panel. If "BAT OK" is not indicated, charging is required.
2. Expose the face of the probe to a bright light source and observe the meter response. An increase in the count rate indicates the presence of a light leak in the mylar cover. The cover must be repaired before the instrument can be used.
3. Determine background cpm. (For Eberline PRM-4 with ORNL digital counter see Sect. 20.1.6.9).
4. Place probe in contact with the ^{230}Th check source.
5. Take a reading of the check source (gross cpm).
6. Net cpm (gross cpm - background cpm) must agree with laboratory accepted limits (approximately ±20%) of the reading taken during the previous field check. (See System Adjustments, Sect. 20.1.6.8.)
7. If the net counts are within the acceptable range, the instrument is now ready for use. If the reading is out of the acceptable range, do not use the instrument but send it to ESOD Standards Laboratory according to the procedure of Sect. 20.1.6.5.
8. Enter into the Portable Instrument Log Book the instrument number, source number, net counts, date, and signature.

20.1.6.6 Calculations

Net cpm = gross cpm - background cpm,
and dpm = cpm X dpc.

20.1.6.7 Log Book Entries

Verify that all log book entries have been made in the appropriate log book in accordance with this procedure and Equipment Calibration Records, Sect. 16.3. Verify that the records technologist has been notified following laboratory calibration and that calibration data has been recorded.

20.1.6.8 System Adjustments

High voltage may be adjusted by the instrument technologist in the field to correct for Probe "dead spots." This adjustment should be noted in the Portable Instrument Log Book.

20.1.6.9 Special Notes and Instruments

For the Eberline PRM-4 Count Rate Meter, use ORNL digital counter box on side of the instrument up to 200 cpm. Above 200 cpm, use meter on main body of instrument.

20.2 CALIBRATION OF GAS FLOW PROPORTIONAL ALPHA COUNTERS

20.2.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration and field check of portable gas flow proportional alpha counters.

20.2.2 Applicability

This procedure is applicable to all standard portable gas flow proportional alpha counters in the ORNL-RASA program.

20.2.3 References

1. Sect. 13.2, Alpha Radiation Measurements
2. Eberline Gas Flow Proportional Alpha Counter Model PAC-4G Technical Manual
3. Eberline Gas Flow Proportional Probe Model AC-21/AC-21B Technical Manual
4. ANSI N323-1978 Radiation Protection Instrumentation Test and Calibration (for guidance only)

20.2.4 Definitions and Abbreviations

20.2.4.1 Definitions

LOG BOOK. At the ORNL-RASA Laboratory, the Instrument Calibration Log Book will be used for all calibration data. At a survey site, the Portable Instrument Log Book will be used for all calibration related field activities.

CALIBRATED INSTRUMENTS FILE. Calibration Records external to the Log Book maintained at the ORNL-RASA Laboratory by the records technologist.

Also see Sect. 1.5 of this manual, Terminology.

20.2.4.2 Abbreviations

cpm Counts per minute

dpm Disintegrations per minute

dpc Disintegrations per count

ANSI American National Standards Institute

EOSD Environmental and Occupational Safety Division, ORNL

Also see Sect. 1.5 of this manual, Terminology.

20.2.5 Responsibilities

The instrument technologist will be responsible for implementation of this procedure.

20.2.6 Procedure

20.2.6.1 Equipment and Supplies

1. Eberline Gas Flow Proportional Alpha Counter Model PAC-4G
2. Eberline Gas Flow Proportional Probe Model AC-21

20.2.6.2 Radiation Sources

Eberline NBS Traceable Sources or their equivalent.

1. #10945, ^{230}Th, 9710 dpm, calibration date: 7-17-78
2. #10944, ^{230}Th, 3940 dpm, calibration date: 7-17-78
3. #10941, ^{230}Th, 1170 dpm, calibration date: 7-17-78

20.2.6.3 Calibration Frequency

Primary laboratory calibration is performed at least quarterly and immediately following any adjustment to or maintenance of the instrument. No field calibration is performed, but a field operation check is performed at least daily during use.

20.2.6.4 Applicable Standards

ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration, is the applicable standard for this procedure (for guidance only).

20.2.6.5 Calibration Procedure

Laboratory calibration

1. Notify ORNL EOSD that the instrument is to be sent out for calibration and that a radiological survey and clearance for shipment of the instrument is requested.
2. Following the radiological survey, EOSD personnel will place a "green tag" (contamination tag, ORNL Form Number UCN-14) on the instrument approving it for shipment to ORNL EOSD Standard Laboratory. If radioactive contamination exists, decontamination of the instrument by RASA personnel is required.
3. Send the instrument to ORNL EOSD Standards Laboratory for calibration.
4. Following calibration and upon receipt of the instrument, verify the instrument identification and probe numbers, and that EOSD Standards Laboratory has affixed a calibration tag to the instrument.
5. Notify the records technologist that the instrument has been calibrated. Supply the records technologist with the instrument number, date of calibration, and the EOSD Standards Laboratory Calibration Value (dpc).

Field check

1. Check battery condition by setting "ON-OFF-BATT" switch in "BATT" position and observing the PAC-4G meter. If the needle indicator does not fall within the "good" battery range on the dial, battery replacement is mandatory. Pull gas flow value to "purge" (full out) position for approximately one minute. Check gas flow rate by switching the gas flow valve to the "operate" position and igniting gas at exit port on the probe. If flame is not nominally 1-in. high, readjust to 1-in. using set screw adjustment. (Verify that the probe cover is in place.) See Sect. 20.1.6.9; Eberline Technical Manual for Model PAC-4G Gas Flow Proportional Alpha Counter; and Sect. 13.2, Alpha Radiation Measurements.
2. Determine background cpm.
3. Place the probe in contact with the check source.

4. Take reading of check source (gross cpm). See Sect. 20.1.6.2.
5. Net cpm (gross cpm - background cpm) must agree within laboratory acceptance limits (approximately ±20%) for the check source being used.
6. If the reading obtained in the preceding step is within the acceptable range, the instrument is now ready for use. If the reading is out of the acceptable range, do not use instrument and recalibrate following Sect. 20.1.6.5.

20.2.6.6 Calculations

Net cpm = gross cpm - background cpm,

and dpm = dpc X cpm.

20.2.6.7 Log Book Entries

1. Verify that appropriate data have been entered in the Survey Instruments Log Book.
2. Verify that the appropriate data have been supplied to the records technologist.
3. The records technologist enters appropriate data in Calibrated Instrument File.

20.2.6.8 System Adjustments

See Sect. 20.1.6.5 of this procedure; Eberline Gas Flow Proportional Alpha Counter Model PAC-4G Technical Manual, and Eberline Gas Flow Proportional Probe Model AC-21/AC-21B Technical Manual for in-field system maintenance adjustments (i.e., high voltage).

20.2.6.9 Special Notes and Instructions

Replace batteries every 24 h of use or immediately after battery check (see Sect. 20.1.6.5) indicates weak batteries.

20.3 CALIBRATION OF ALPHA SMEAR COUNTERS

20.3.1 Purpose

The purpose of this procedure is to provide a method for the laboratory and field calibration of alpha smear counters.

20.3.2 Applicability

This procedure applies to all standard alpha smear counters used in the ORNL-RASA program.

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

20.3.3 References

1. Sect. 13.4, Transferable Alpha and Beta-Gamma Measurements
2. Sect. 16.3, Equipment Calibration Records

20.3.4 Definitions and Abbreviations

20.3.4.1 Definitions

LOG BOOK. Each alpha smear counter has its own dedicated log book that is retained with the instrument at all times.

Also see Sect. 1.5 of this manual, Terminology.

20.3.4.2 Abbreviations

NBS National Bureau of Standards

dpm Disintegrations per minute

cpm Counts per minute

Also see Sect. 1.5 of this manual, Terminology.

20.3.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure.

20.3.6 Procedure

20.3.6.1 Laboratory Calibration

Equipment and Supplies

Alpha smear counting equipment specified by the procedure of Sect. 13.4, Transferable Alpha and Beta-Gamma Measurements. (One system is located on each of two mobile laboratories.)

Radiation sources

Eberline NBS Traceable Sources or their equivalent.

1. #10945, ^{230}Th, 9710 dpm, calibration date: 7-17-78
2. #10944, ^{230}Th, 3940 dpm, calibration date: 7-17-78
3. #10941, ^{230}Th, 1170 dpm, calibration date: 7-17-78

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Calibration frequency

Laboratory calibration is performed semi-annually or following instrument repair.

Applicable standards

None.

Calibration procedure

1. Record alpha smear counter control settings in the Alpha Smear Counter Log Book.
2. Following Transferable Alpha and Beta-Gamma Measurements, Sect. 13.4 (alpha smear counter operation), determine background counts for 10 min. and record the counts in the Alpha Smear Counter Log Book for the system being calibrated.
3. Place the standard radiation source in the detector.
4. Determine the source counts for 10 min and record the counts in the Alpha Smear Counter Log Book.

Calculation

Calculate alpha smear counter efficiency using the formula

Alpha smear

$$\text{counter efficiency (cpm/dpm)} = \frac{\frac{SC}{ST} - \frac{BC}{BT}}{A} ,$$

and

$$\text{efficiency (\%)} = \text{(cpm/dpm)} \times 100 ,$$

where

SC = counts from calibration source. (See Sect. 6.1.5.4)
ST = source counting time in minutes. (See Sect. 6.1.5.4)
BC = background counts. (See Sect. 6.1.5.2.)
BT = background counting time in minutes. (See Sect. 6.1.5.2)
A = source strength (dpm).

Log book entries

1. Verify that all Alpha Smear Counter Log Book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3, including the following data: date of most recent calibration, signature of calibrator, alpha smear efficiency, number and type of source used, unusual or special use conditions, and date of next required calibration.
2. Enter all repair/maintenance operations performed on alpha smear counter into the Alpha Smear Counter Log Book including date, signature of repair/maintenance person, and nature of work performed.
3. Report alpha smear counter identification number, calibration date, calibration source number, and alpha smear counter efficiency, to records technologist for inclusion in Calibrated Instrument File.

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

System adjustments

If the system efficiency determined in calculations (Sect. 6.1.6), does not fall between 25 and 35%, proceed as follows:

1. Adjust high voltage within a range of ±20% of the recommended setpoint in Transferable Alpha and Beta-Gamma Measurements, Sect. 13.4 (alpha smear counter operation).
2. Adjust Fine Gain within a range of ±20% of the recommended setpoint specified in Transferable Alpha, Beta-Gamma Measurements, Sect. 13.4 (alpha smear counter operation).
3. Repeat calibration procedure (Sect. 6.1.5) and calculations (Sect. 6.1.6). Record new settings as in (1) and (2) above.
4. If system efficiency determined in Sect. 6.1.6 remains outside of 25 to 35% range, contact proper ORNL-RASA instruments technologist responsible for the alpha smear counter system.

Special notes and instructions

None.

20.3.6.2 Field Check

Equipment and supplies

Alpha smear counting equipment specified by Transferable Alpha and Beta-Gamma Measurements, Sect. 13.4. (One system is located on each of two mobile laboratories.)

Radiation sources

Eberline NBS Traceable Sources, or their equivalent.

1. #10945, ^{230}Th, 9710 dpm, calibration date: 7-17-78
2. #10944, ^{230}Th, 3940 dpm, calibration date: 7-17-78
3. #10941, ^{230}Th, 1170 dpm, calibration date: 7-17-78

Calibration frequencies

A field calibration check is performed before each use.

Applicable standards

None.

Calibration procedure

1. Following Transferable Alpha and Beta-Gamma Measurements, Sect. 13.4 (alpha smear counter operation), determine background counts for 10 min.
2. Install check source in detector and determine gross counts for 10 min.
3. If net counts (gross counts less background) are within ±20% of the value determined in the field check immediately preceding this measurement, enter net counts, date, and signature in the Alpha Smear Counter Log Book.
4. If the net counts (gross counts less background) differ by more than ±20%, conduct laboratory calibration by following Sect. 6.1.5.

Calculations

None.

Log book entries

Verify that all Alpha Smear Counter Log Book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.

System adjustments

None.

Special notes and instructions

None.

20.4 CALIBRATION OF ALPHA SPECTROMETRY SYSTEMS

20.4.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration of alpha spectrometry systems.

20.4.2 Applicability

This procedure applies to all standard alpha spectrometry systems used in the ORNL-RASA program.

20.4.3 References

1. Sect. 13.10, Measurement of Radon Daughter Activities in Air Samples
2. Sect. 16.3, Equipment Calibration Records

20.4.4 Definitions and Abbreviations

20.4.4.1 Definitions

CALIBRATED INSTRUMENT FILE. Calibration records external to log books maintained at the ORNL-RASA Laboratory by the records technologist.

LOG BOOK. Alpha Spectrometer Log Book located in the mobile laboratory. One log book for each of the two mobile laboratories.

Also see Sect. 1.5 of this manual, Terminology.

20.4.4.2 Abbreviations

dpm Disintegrations per minute

cpm Counts per minute

20.4.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure, and the records technologist is responsible for the maintenance of retrievable records and data as supplied by the instrument technologist.

20.4.6 Procedure

20.4.6.1 Equipment and Supplies

Equipment specified in Measurement of Radon Daughter Activities in Air Samples, Sect. 13.10, for alpha spectrometry, including an alpha spectrometry multichannel analyzer and detector module.

20.4.6.2 Radiation Sources

The following sources or their equivalent:

1. ORNL #1, ^{241}Am, 6096 dpm ± 0.8%, calibration date: 10-6-81 (NBS)
2. ORNL #2, ^{241}Am, 4936.2 dpm ± 0.8%, calibration date: 10-6-81 (NBS)
3. ORNL #3, ^{241}Am, 5093.4 dpm ± 0.8%, calibration date: 10-6-81 (NBS)
4. ^{228}Th (check source), 2000 cpm at 2 π geometry

20.4.6.3 Calibration Frequency

Laboratory calibration is performed quarterly (at a minimum) and immediately following maintenance, repair, or adjustment of the equipment and when improper system operation is suspected. No field calibration is performed; a field operational check is performed before each use of an instrument.

20.4.6.4 Applicable Standards

None.

20.4.6.5 Calibration Procedure

Laboratory calibration

1. Following instrument operating instructions in Measurement of Radon Daughter Activities in Air Samples, Sect. 13.10, install ^{228}Th check source in sample holder.
2. Verify spectral alignment by observing the relationship between channel 445 and the 8.78 MeV peak of ^{228}Th. The 8.78 MeV peak should be coincident with channel 445, as observed on the CRT display.
3. If necessary, adjust coarse and fine gain controls on linear amplifier of alpha spectrometry system to achieve coincidence (see Sect. 6.8, System Adjustments).
4. Set integration region between channels 160 and 308.

5. Remove ^{228}Th check source from detector.
6. Determine total background counts over a 10-min period, and record counts in Alpha Spectrometer Log Book.
7. Install ^{241}Am source in detector and determine total counts over a 10-min period and record in Alpha Spectrometer Log Book.
8. Perform calculations as shown in Sect. 6.6, Calculations.
9. Enter into Alpha Spectrometer Log Book the following data: date, system efficiency, coarse and fine gain settings, calibration source number, and signature of calibrator.
10. Notify the records technologist that the system has been calibrated and supply the calibration date and system efficiency for inclusion in the Calibrated Instrument File.

Field check

Following instrument operating instructions in Measurement of Radon Daughter Activities in Air Samples, Sect. 13.10, perform items (1) through (6) from preceding laboratory calibration.

20.4.6.6 Calculations

Laboratory calibration calculations

Calculate system efficiency using the following formula:

$$E = \frac{cpm - B}{A} \times 100 ,$$

where

E = system efficiency in % ,
cpm = gross counts per minute ,
B = background cpm ,
A = source activity.

20.4.6.7 Log Book Entries

1. Verify that all log book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.
2. Verify that the records technologist has been informed of a system laboratory calibration and that required data has been furnished for inclusion in the Calibrated Instrument File.

20.4.6.8 System Adjustments

To achieve coincidence between the 8.78 MeV peak of the thorium spectrum, adjust fine and coarse gain controls of linear amplifier on alpha spectrometry apparatus.

20.4.6.9 Special Notes and Instructions

None.

20.5 CALIBRATION OF GEIGER-MUELLER SURVEY METERS

20.5.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration and field check of portable Geiger-Mueller (G-M) survey meters.

20.5.2 Applicability

This procedure is applicable to all standard portable G-M survey meters used by ORNL-RASA.

20.5.3 References

1. Sect. 16.3, Equipment Calibration Records
2. Eberline Geiger Counter, Model E-120/E-120G Technical Manual
3. ANSI N323-1978 Radiation Protection Instrumentation Test and Calibration (for guidance only)

20.5.4 Definitions and Abbreviations

20.5.4.1 Definitions

LOG BOOK. At the ORNL-RASA Laboratory, the Instrument Calibration Log Book will be used for all laboratory calibration data. At a survey site, the Portable Instrument Log Book will be used for all calibration-related field activities.

Also see Sect. 1.5 of this manual, Terminology.

20.5.4.2 Abbreviations

CAM-1 Depleted uranium check source

cpm Counts per minute

dpm Disintegrations per count

EOSD Environmental and Occupational Safety Division

ANSI American National Standards Institute

Also see Sect. 1.5 of this manual, Terminology.

20.5.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure, and the records technologist is responsible for maintaining retrievable calibration data and records as supplied by the instrument technologist.

20.5.6 Procedure

20.5.6.1 Equipment and Supplies

A portable G-M survey meter (Eberline E-120/E-120G or equivalent).

20.5.6.2 Radiation Sources

Depleted uranium (CAM-1) check source or equivalent. Source strength nominally 18,000 net cpm with Thyac III gamma scintillation probe. Approximately 7000 gross cpm open window with G-M Survey Meter.

20.5.6.3 Calibration Frequency

Primary laboratory calibration is performed at least quarterly and immediately following any adjustment to or maintenance of the instrument. No field calibration is performed; field operation check is performed at least daily during use.

20.5.6.4 Applicable Standards

ANSI 323-1978 Radiation Protection Instrumentation Test and Calibration (for guidance only).

20.5.6.5 Calibration Procedure

Laboratory calibration

1. Notify ORNL EOSD that the instrument is to be sent out for calibration and that a radiological survey and clearance for shipment of the instrument are requested.
2. Following the radiological survey, EOSD personnel will place a "green tag" (contamination tag, ORNL Form Number UCN-14) on the instrument approving it for shipment to ORNL EOSD Standards Laboratory. If radioactive contamination exists, notify site leader to arrange for decontamination of the instrument.
3. Send instrument to ORNL EOSD Standards Laboratory for calibration.
4. Following calibration and on receipt of the instrument, verify the instrument identification and probe numbers and that EOSD Standards Laboratory has affixed a calibration tag to the instrument.
5. Notify the records technologist that the instrument has been calibrated. Supply the records technologist with the instrument number, date of calibration, and the EOSD Standards Laboratory Calibration Value (dpc).
6. Enter into the Instrument Calibration Log Book the instrument number, date of calibration, and the EOSD Standards Calibration Value (dpc).

Field check

1. Following the Eberline Geiger Counter, Model E-120/E-120G Technical Manual procedures, check battery condition by placing the selector control in the Batt position and reading the meter. Replace batteries immediately if the indicator shows low battery power. (See Sect. 6.9.)
2. Set response time control at midpoint of its rotation and the range switch to the appropriate range (maximum needle deflection without going off scale).
3. Determine background cpm.
4. If meter movement is erratic or insensitive, adjust the time constant (response time control) to achieve uniform response without excess meter movement.
5. Place probe in direct contact with the CAM-1 check source and read cpm.
6. Determine gross cpm. Take reading in cpm. Push reset button (meter display should go to zero) and release button (meter display should return to position of original reading ±10%).
7. If the two readings (step 6) do not agree by <±10%, return to ORNL for repair and recalibration, according to Sect. 6.5.1 of this procedure.
8. Determine the net cpm. The net cpm reading must agree within laboratory accepted limits (approximately ±20%) with the reading taken during the previous field check. (See System Adjustments, Sect. 6.8 of this procedure.)
9. If the net cpm is within the acceptable range (as specified in step 8), the instrument is now ready for use. If the reading is out of the acceptable range, return to ORNL for repair and recalibration according to Sect. 6.5.1 of this procedure.
10. Enter into the Portable Instrument Log Book the instrument number, source number, net cpm, date, and signature of instrument technologist.

20.5.6.6 Calculations

$$\text{Net cpm} = \text{gross cpm} - \text{background cpm} .$$

20.5.6.7 Log Book Entries

1. Verify that all log book entries have been made in the appropriate log book in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.
2. Verify that the records technologist has been notified following laboratory calibration and that calibration data has been recorded.

20.5.6.8 System Adjustments

1. High voltage may be adjusted by the instrument technologist in the field to correct for probe "dead spots." Adjustments should be recorded in the Portable Instrument Log Book.

20.5.6.9 Special Notes and Instructions

1. Instrument may be calibrated to thorium or other source, instead of radium, upon request.
2. Replace batteries every 24 h of use or immediately after batteries are found to be weak.

20.6 CALIBRATION OF ONSITE GAMMA SPECTROMETERS

20.6.1 Purpose

The purpose of this procedure is to provide a method for the calibration of onsite gamma spectrometers.

20.6.2 Applicability

This procedure applies to the two onsite gamma spectrometry systems used by ORNL-RASA and commonly referred to as the Adam and Eve systems.

20.6.3 References

1. Sect. 13.8, Onsite Gamma Spectrometry
2. Sect. 16.3, Equipment Calibration Records
3. Sect. 20.17, Calibration of Charcoal Canisters
4. Nuclear Data ND 100 Pulse Height Analyzer Technical Manual
5. Tracor Northern TN 1314 Display Unit Technical Manual
6. Tracor Northern TN 1706 Pulse Height Analyzer Technical Manual
7. ORTEC 490B Linear Amplifier Technical Manual
8. ORTEC 456 High Voltage Power Supply Technical Manual
9. Tennelec Tennebin 3 Nimbin Power Supply Technical Manual

20.6.4 Definitions and Abbreviations

20.6.4.1 Definitions

BACKGROUND COUNTS. Total number of counts resulting from naturally occurring radiation in system environment and system noise.

GROSS COUNTS. Total number of counts resulting from sample being counted, naturally occurring radiation in system environment, and system noise.

LOG BOOK. Adam system and Eve system log books maintained with the counting system.

NET COUNTS. Total number of counts resulting from a sample counted (gross counts - background counts).

Also see Sect. 1.5 of this manual, Terminology.

20.6.4.2 Abbreviations

cpm	Counts per minute
L	Liter
m	Meter
pCi	Picocurie

Also see Sect. 1.5 of this manual, Terminology.

20.6.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure, and the records technologist is responsible for maintaining calibration data that is supplied by the instrument technologist in the Calibrated Instrument File.

20.6.6 Procedure

20.6.6.1 Equipment and Supplies

Adam or Eve onsite gamma spectrometry system (see Exhibit 20.1, Component List for Onsite Gamma Spectrometry Systems) and Dunnite or reagent-grade salt are necessary to perform this procedure.

20.6.6.2 Radiation Sources

1. ^{137}Cs low-level check source (12.0 μCi) #7286-5 or equivalent
2. Soil standards series containing 2 to 150 pCi/g of ^{226}Ra. Standards are generated by ORNL-RASA and compared to NB series soil standards on laboratory gamma spectrometers.

20.6.6.3 Calibration Frequency

Laboratory

Laboratory calibration is performed quarterly, at a minimum, immediately following maintenance and repair, or when defective operation of the system is suspected.

Field

A field check is performed at least twice each day when the system is operating.

20.6.6.4 Applicable Standards

None.

20.6.6.5 Calibration Procedure

Gain adjustment

1. Start mobile laboratory generator, allow system to warm up, start gamma spectrometer (Adam or Eve) and allow to warm up following Sect. 13.8, Onsite Gamma Spectrometry.
2. Install ^{137}Cs check source in system detector.
3. Align channel 852 with the 662 keV peak of the ^{137}Cs. (For the Eve system, rotate cursor knob on the pulse-height analyzer until 852 appears on CRT display. For the Adam system, consult ND 100 Pulse Height Analyzer Technical Manual for detailed discussion and instructions on channel selection.) Peak alignment with channel 852 is achieved by adjusting the gain control on the system linear amplifier.
4. Repeat gain adjustment procedure every 30 min for the first 2 h of operation, then every 2 h.

Determination of conversion factor

1. Install blank (reagent-grade sodium chloride or Dunnite) in detector system. To assure congruent sample geometry, depth of the standard, blank, and all samples to be counted must be equal. (See Sect. 6.9.)
2. Accumulate counts in the two regions of interest (channels 287 to 519 and 709 to 948) for a period of 10 min. For the Eve system, set counter for 10 min, press CLEAR and ACQUIRE switches on the pulse-height analyzer. For the Adam system, consult the ND 100 Pulse Height Analyzer Technical Manual for detailed discussion and instructions on data acquisition procedure.
3. Record background counts for the two regions of interest. For the Eve system, place REGION switch in the CLEAR position. Rotate cursor knob until channel 287 appears on the CRT screen. Place REGION switch in the ENTER position, rotate cursor knob until channel 519 appears on the CRT screen. Place REGOPM switch in the ENTER position and read the accumulated counts for the 287 to 519 region on the CRT. Place REGION switch in the CLEAR position. Repeat this operation using 709 for the initial and 948 for the final values. For the Adam system, consult the ND 100 Pulse Height Analyzer Technical Manual for detailed discussion and instructions on data recovery procedure.
4. Remove blank sample and install the soil standard.
5. Count for 10-min and record accumulated counts by following steps 2 and 3 of this procedure.
6. Remove standard from detector and perform calculations according to Sect. 6.6 of this procedure.
7. Record in Adam or Eve log book the date, calibrator, identification of the soil standard used, and system conversion factor. No calibration stickers are applied to the instrument because normal operation requires use of the log book containing calibration information.

20.6.6.6 Calculations

1. Determine net counts using the equation

$$\frac{(B-a) + (C-b)}{T} = A ,$$

where

B = gross sample counts (287 to 519 window),
a = background counts (287 to 519 window),
C = gross sample counts (709 to 948 window),
b = background counts (709 to 948 window),
T = counting time (min),
A = net counts.

2. Determine calibration conversion factor using the following formula:

$$\frac{W}{A} = Z ,$$

where

W = concentration of standard (pCi/g of ^{226}Ra),
A = net counts (from Eq. 20.1),
Z = conversion factor (pCi/g net cpm).

3. Equations are also programmed into the PET computer system and may be used to facilitate these calculations.

20.6.6.7 Log Book Entries

1. Verify that all log book entries have been made in accordance with this procedure and the procedure of Sect. 16.3, Equipment Calibration Records.
2. Enter all maintenance or repair operations performed on the system into the appropriate (Adam or Eve) log book.
3. Report instrument identification, calibration factor, and date to the records technologist for inclusion in the Calibrated Instrument File.

20.6.6.8 System Adjustments

None.

20.6.6.9 Special Notes and Instructions

For charcoal canister calibration, see Sect. 20.17, Calibration of Charcoal Canisters.

20.7 CALIBRATION OF BETA-GAMMA PANCAKE COUNTERS

20.7.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration and field check of portable beta-gamma pancake counters.

20.7.2 Applicability

This procedure applies to all standard beta-gamma pancake counters used in the RASA program.

20.7.3 References

1. Sect. 13.3, Beta-Gamma Radiation Measurements
2. Sect. 16.3, Equipment Calibration Records
3. Eberline Beta-Gamma Pancake Counter Technical Specification Sheets
4. ANSI N-323-1978, Radiation Protection Instrumentation Test and Calibration

20.7.4 Definitions and Abbreviations

20.7.4.1 Definitions

LOG BOOK. At the ORNL-RASA Laboratory, the Instrument Calibration Log Book will be used for all laboratory calibration data. At a survey site, the Portable Instrument Log Book will be used for all calibration related to field activities.

Also see Sect. 1.5 of this manual, Terminology.

20.7.4.2 Abbreviations

cpm Counts per minute

dpm Disintegrations per minute

EOSD Environmental and Occupational Safety Division

Also see Sect. 1.5 of this manual, Terminology.

20.7.5 Responsibilities

The instrument technologist is responsible for implementation of this procedure, and the records technologist is responsible for maintenance of all calibration records and files generated by this procedure.

20.7.6 Procedure

20.7.6.1 Equipment and Supplies

An Eberline Beta-Gamma Pancake Counter, Calibration Jig (see Exhibit 20.2), and 0.062-in. aluminum absorber plate.

20.7.6.2 Radiation Sources

1. NBS S-2418, ^{90}Sr - ^{90}Y, 10052 ± 452 dpm, calibration date: 8-13-81
2. NBS S-2737, ^{90}Sr - ^{90}Y, 10848 ± 325 dpm, calibration date: 8-13-81
3. NBS S-2738, ^{90}Sr - ^{90}Y, 7401 ± 286 dpm, calibration date: 8-13-81
4. NBS S-1334, ^{99}Tc, 6530 ± 196 dpm, calibration date: 8-13-81
5. NBS S-1345, ^{99}Tc, 6880 ± 206 dpm, calibration date: 8-13-81
6. NBS S-2209, ^{99}Tc, 5880 ± 176 dpm, calibration date: 8-13-81

20.7.6.3 Calibration Frequency

Laboratory

Primary calibration will be performed at least quarterly and immediately following any adjustment to or maintenance of the instrument.

Field

No calibration is performed in the field; field operation check is performed at least daily during use.

20.7.6.4 Applicable Standards

ANSI N-323-1978, Radiation Protection Instrument Test and Calibration (for guidance only) is the applicable standard to be used.

20.7.6.5 Calibration Procedure

Laboratory calibration

1. Notify ORNL EOSD that the instrument is to be sent out for calibration and that a radiological survey and clearance for shipment of the instrument are requested.
2. Following the radiological survey, EOSD personnel will place a "green tag" (contamination tag, ORNL Form Number UCN-14) on the instrument approving it for shipment to ORNL EOSD Standards Laboratory. If radioactive contamination exists, notify the site leader who will arrange for decontamination of the instrument.
3. Send the instrument to ORNL EOSD Standards Laboratory for calibration.

4. Following calibration and on receipt of the instrument, verify the instrument identification and probe numbers and that EOSD Standards Laboratory has affixed a calibration tag to the instrument.
5. Notify the records technologist that the instrument has been calibrated. Supply the records technologist with the instrument number, date of calibration, and the EOSD Standards Laboratory Value (dpc).
6. Enter into the Instrument Calibration Log Book the instrument number, date of calibration, and the EOSD Standards Calibration Value (dpc).

Field check

1. Check pancake counter batteries by placing selector switch in "battery" position and noting upscale deflection of meter (see Sect. 6.9).
2. Place counter on calibration jig and determine background cpm.
3. Place radiation source in source holder, place counter on source holder, and determine cpm.
4. Insert absorber plate between source and counter and determine cpm.
5. Calculate the total net cpm and beta-gamma ratio as described under Calculations (see Sect. 6.6).
6. Net values obtained for total net cpm and beta-gamma ratio must agree within laboratory accepted limits (approximately ±20%) of the reading during the previous field check. See System Adjustments, Sect. 6.8.
7. If the values obtained in step 5 are within the acceptable range, the counter is now ready for use. If the readings are out of the acceptable range, return the instrument to the ORNL-RASA Laboratory for repair and recalibration following Sect. 6.5.1.
8. Enter into the Portable Instrument Log Book the instrument number, source number, net cpm, beta-gamma ratio, and signature of instrument technologist.

20.7.6.6 Calculations

1. Total cpm:

   Total net cpm = gross cpm - background cpm,

2. Beta-gamma ratio:

   $$\text{Beta-gamma ratio} = \frac{O}{C},$$

   where

   O = net cpm without absorber,
   C = Net cpm with absorber.

20.7.6.7 Log Book Entries

1. Verify that all log book entries have been made in the appropriate log book in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.
2. Verify that the records technologist has been notified following laboratory calibration and that the calibration data have been recorded.

20.7.6.8 System Adjustments

High voltage may be adjusted by the instrument technologist in the field to correct for probe "dead spots." This adjustment should be noted in the Portable Instrument Log Book.

20.7.6.9 Special Notes and Instructions

Replace batteries after every 24 h of use.

20.8 CALIBRATION OF BETA-GAMMA SMEAR COUNTERS

20.8.1 Purpose

The purpose of this procedure is to provide a method for the laboratory and field calibration of beta-gamma smear counters.

20.8.2 Applicability

This procedure applies to all standard beta-gamma smear counters used in the RASA program.

20.8.3 References

1. Sect. 13.4, Transferable Alpha and Beta-Gamma Measurements
2. Sect. 16.3, Equipment Calibration Records

20.8.4 Definitions and Abbreviations

20.8.4.1 Definitions

LOG BOOK. Each beta-gamma smear counter has its own dedicated log book. It should accompany the instrument at all times.

Also see Sect. 1.5 of this manual, Terminology.

20.8.4.2 Abbreviations

cpm Counts per minute

dpm Disintegrations per minute

Also see Sect. 1.5 of this manual, Terminology.

20.8.5 Responsibilities

The laboratory technologist is responsible for the implementation of this procedure, and the records technologist is responsible for the maintenance of all calibration records and files generated by this procedure.

20.8.6 Procedure

20.8.6.1 Laboratory Calibration

Equipment and supplies

Beta-gamma smear counting equipment specified by Sect. 13.4, Transferable Alpha and Beta-Gamma Measurements.

Radiation sources

The following NBS sources or their equivalent are used in this procedure:

1. NBS S-2418, ^{90}Sr - ^{90}Y, 10052 ± 452 dpm, calibration date: 8-13-81
2. NBS S-2737, ^{90}Sr - ^{90}Y, 10848 ± 325 dpm, calibration date: 8-13-81
3. NBS S-2738, ^{90}Sr - ^{90}Y, 7901 ± 286 dpm, calibration date: 8-13-81
4. NBS S-1334, ^{99}Tc, 6530 ± 196 dpm, calibration date: 8-13-81
5. NBS S-1345, ^{99}Tc, 6880 ± 206 dpm, calibration date: 8-13-81
6. NBS S-2209, ^{99}Tc, 5880 ± 176 dpm, calibration date: 8-13-81

Calibration frequency

Laboratory calibration of instruments is performed quarterly or following instrument repair or maintenance.

Applicable standards

None.

Calibration procedure

1. Following the procedure of Sect. 13.4, Transferable Alpha and Beta-Gamma Measurements (beta-gamma smear counter operation), determine background counts for 10 min and record in Beta-Gamma Log Book for system being calibrated.
2. Place selected standard radiation source in detector assembly. (Note: Do not install in the inverted position.)
3. Determine source counts for 10 min and record in Beta-Gamma Smear Counter Log Book.
4. Record beta-gamma smear counter control settings in Beta-Gamma Smear Counter Log Book.

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Calculations

1. Calculate source decay correction for ^{90}Sr using the formula

$$A = A_0 e^{-\lambda t} ,$$

where

A = current activity,
A^o = activity at time 0,
λ = decay constant for ^{90}Sr ($year^1$) = 0.03 $year^1$,
t = time from NBS calibration to present (years).

2. Calculate beta-gamma smear counter efficiency (E^c) using the formula

$$E_c = (\%) = \frac{\frac{SC}{ST} - \frac{BC}{BT}}{A} \times 100$$

where

E^c = beta-gamma counter efficiency,
SC = counts from calibration source,
ST = source counting time in minutes,
BC = background counts,
BT = background counting time in minutes,
A = activity at time of counting.

Log book entries

1. Verify that all Beta-Gamma Smear Counter Log Book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3, including the following data: date of most recent calibration, signature of calibrator, counter efficiency, number and type of source used, unusual or special use conditions, and date of next required calibration.
2. Enter all maintenance or repair operations performed on beta-gamma smear counter into the Beta-Gamma Smear Counter Log Book including date, signature of repair/maintenance person, and nature of work performed.
3. Report beta-gamma smear counter identification number, calibration date, calibration source number, and beta-gamma smear counter efficiency to records technologist for inclusion in Calibrated Instrument File.

System adjustments

If the system efficiency determined in calculations (Sect. 6.1.6) does not fall between 25 and 35%, proceed as follows:

1. Adjust high voltage within a range of ±20% of the recommended setpoint in Transferable Alpha and Beta-Gamma Measurements, Sect. 13.4 (beta-gamma smear counter operation).
2. Adjust fine gain within a range of ±20% of the recommended setpoint specified in the Transferable Alpha and Beta-Gamma Measurements, Sect. 13.4 (beta-gamma smear counter operation).
3. Repeat calibration procedure (see Sect. 6.1.5) and calculations (Sect. 6.1.6).
4. If system efficiency determined in Sect. 6.1.6 remains outside of 25 to 35% range, contact ORNL-RASA instrument technologist responsible for the beta-gamma smear counter system.

Special notes and instructions

None.

20.8.6.2 Field Check

Equipment and supplies

Beta-gamma smear counting equipment specified by Transferable Alpha and Beta-Gamma Measurements, Sect. 13.4 (one system is located on each of two mobile laboratories).

Radiation sources

See Sect. 6.1.2 of this procedure.

Calibration frequencies

Field check prior to each use.

Applicable standards

None.

Calibration procedure

1. Following Transferable Alpha and Beta-Gamma Measurements, Sect. 13.4 (beta-gamma smear counter operation), determine background counts for 10 min.
2. Install check source in detector and determine gross counts for 10 min.
3. If net counts (gross counts less background) are within ±20% of the value determined in the field check immediately preceding this measurement, enter net counts, date, and signature in the Beta-Gamma Smear Counter Log Book.
4. If the net counts (gross counts less background) differ by more than ±20%, conduct laboratory calibration by following Sect. 6.1.5.

Calculations

Net counts = gross counts - background counts

Log book entries

Verify that all Beta-Gamma Smear Counter Log Book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.

System adjustments

None.

Special notes and instructions

None.

20.9 CALIBRATION OF PRESSURIZED ION CHAMBER

20.9.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration and field check of Pressurized Ion Chambers.

20.9.2 Applicability

This procedure applies to all standard pressurized ion chambers used in the RASA program.

20.9.3 References

1. Sect. 13.5, Gamma Exposure Rate Measurements (Pressurized Ion Chamber)
2. Sect. 16.3, Equipment Calibration Records
3. Sect. 18.1, Procurement of Services and Equipment
4. ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration (for guidance only)
5. Reuter-Stokes RSS-111, Area Monitor System Operational Manual

20.9.4 Definitions and Abbreviations

20.9.4.1 Definitions

LOG BOOK. At the ORNL-RASA Laboratory, the Instrument Calibration Log Book will be used for all laboratory calibration. At a survey site, the Portable Instrument Log Book will be used for all calibration related field activities.

CALIBRATED INSTRUMENT FILE. Calibration records external to the log book maintained at the ORNL-RASA Laboratory by the records technologist.

Also see Sect. 1.5 of this manual, Terminology.

20.9.4.2 Abbreviations

μR/h Microroentgen per hour

ANSI American National Standards Institute

EOSD Environmental and Occupational Safety Division

Also see Sect. 1.5 of this manual, Terminology.

20.9.5 Responsibilities

The instrument technologist is responsible for implementing this procedure, and the records technologist is responsible for maintaining retrievable calibration data and records as supplied by the instrument technologist.

20.9.6 Procedure

20.9.6.1 Equipment and Supplies

A Reuter-Stokes RSS-111, Area Monitoring System (PIC) and a calibrated voltage standard (0-10 vdc 0.01 vdc resolution)

20.9.6.2 Radiation Sources

^{60}Co check source approximately 11.0 μCi (11-1-74)

20.9.6.3 Calibration Frequency

Primary laboratory calibration will be performed at least quarterly and immediately following any adjustment or maintenance of the instrument. No field calibration is performed; field operational check is performed before each use.

20.9.6.4 Applicable Standards

ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration is the applicable standard to be used (for guidance only).

20.9.6.5 Calibration Procedure

Laboratory calibration

1. Notify ORNL EOSD that instrument is to be sent out for calibration and that a radiological survey and clearance for shipment of the instrument are requested.
2. Following the radiological survey, EOSD personnel will place a "green tag" (contamination tag, ORNL Form Number UN-14), on the instrument approving it for shipment. If radioactive contamination exists, notify the site leader who will arrange for decontamination of the instrument.

3. Send the instrument to Reuter-Stokes for calibration via ORNL Shipping/Receiving Department. Arrangements must be previously made with Reuter-Stokes for work and appropriate purchasing procedures followed according to the procedure of Sect. 18.1, Procurement of Services and Equipment.
4. Following calibration and on receipt of the instrument, verify the instrument identification and probe numbers and that the calibration facility has provided adequate calibration data on the instrument.
5. Notify the records technologist that the instrument has been calibrated. Supply the records technologist with the instrument number, date of calibration, and the calibration facility calibration value (μR/h).
6. Enter into the Instrument Calibration Log Book the instrument number, date of calibration, and the calibration value (μR/h).
7. Perform field check following Sect. 6.5.2 of this procedure and record all required data in Instrument Calibration Log Book.

Field check

Battery check.

1. Test 300 V dry cell by turning on DISPLAY/RECORDER switch, turn ELECTROMETER switch to zero, MODE switch to BATT position, and simultaneously press PUSH TO READ and 300 V push buttons. The percentage of charge status will appear on digital display. If percentage of charge falls below 85%, replace battery according to paragraph 4.3 of Reuter-Stokes RSS-111 Area Monitor System Operational Manual.
2. Test -14, +14, and +12 batteries by depressing each of the three push buttons marked -14, +14, and +12 and noting the meter indication on one of the three meters immediately above the push button. If meter indicator is in or near the shaded area of the meter, recharge batteries according to paragraph 4.2 of Reuter-Stokes RS-111 Area Monitor System Operational Manual.

Check source test.

1. Following External Gamma Exposure Rate Measurements (Pressurized Ion Chamber), Sect. 13.5, determine instrument background by pressing PUSH TO READ and reading μR/h value. (Verify that no gamma radiation sources are in the proximity of the detector.)
2. Place check source on top of PIC detector assembly and align with source position marker outlined on body of detector.
3. Wait a minimum of 5 s, press PUSH TO READ, and read μR/h value.
4. Enter net μR/h value in Portable Instrument Log Book.
5. If μR/h value determined differs from last field check value by less than the Laboratory acceptance limits (approximately ±20%) the instrument is ready for use. If μR/h determined differs from last field check value by more than the Laboratory acceptance limits (approximately ±20%) send instrument out for laboratory calibration following Sect. 6.5.1 of this procedure.

Electronic check

1. Connect calibrated voltage standard to Analog Output BNC Connector on front panel.
2. Adjust voltage to 0.5 vdc, wait 5 s, press PUSH TO READ, and record display value (μR/h) in log book.
3. Repeat line 2 for voltage values of 1.0, 2,0, 4.0, 6.0, 8.0, and 10.0.
4. Nominal μR/h values for each applied voltage should be as follows:

vdc	μR/h
0.5	25
1.0	50
2.0	100
4.0	200
6.0	300
8.0	400
10.0	500

5. If μR/h values for each applied voltage are within ±5% of the values determined immediately following laboratory calibration (see Sect. 6.5.1), the electronics are within calibration limits. Proceed to Sect. 6.5.2.2, Check Source Test. If the values determined differ by >±5%, send the instrument out for laboratory calibration following Sect. 6.5.1 of this procedure.

20.9.6.6 Calculations

Net μR/h = gross μR/h - background μR/h.

20.9.6.7 Log Book Entries

Verify that all log book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.

20.9.6.8 System Adjustments

None.

20.9.6.9 Special Notes and Instructions

None.

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

20.10 CALIBRATION OF PORTABLE GAMMA-SCINTILLATION DETECTORS

20.10.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration, field check, and onsite cross-calibration of portable gamma-scintillation detectors.

20.10.2 Applicability

This procedure applies to all standard portable gamma-scintillation detectors used in the ORNL-RASA program.

20.10.3 References

1. Sect. 13.5, Gamma Exposure Rate Measurements (Pressurized Ion Chamber)
2. Sect. 16.3, Equipment Calibration Records
3. Sect. 20.9, Calibration of Pressurized Ion Chamber
4. Instruction Manual for Model 490, THYAC III (Victoreen Inc.)
5. ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration

20.10.4 Definitions and Abbreviations

20.10.4.1 Definitions

LOG BOOK. At the ORNL-RASA Laboratory, the Instrument Calibration Log Book will be used for all laboratory calibration data. At a survey site, the Portable Instrument Log Book will be used for all calibration-related field activities.

Also see Sect. 1.5 of this manual, Terminology.

20.10.4.2 Abbreviations

ANSI American National Standards Institute

cpm Counts per minute

EOSD Environmental and Occupational Safety Division

NaI(Tl) Thallium activated sodium iodide crystal

CAM-1 Depleted uranium check source

PIC Pressurized ion chamber

Also see Sect. 1.5 of this manual, Terminology.

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

20.10.5 Responsibilities

The instrument technologist is responsible for implementing this procedure, and the records technologist is responsible for maintaining retrievable calibration data and records as supplied by the instrument technologist.

20.10.6 Procedure

20.10.6.1 Equipment and Supplies

Portable Gamma-Scintillation Detector (Victoreen Model 490 THYAC III) Ratemeter with 489-55 NaI(Tl) Scintillation Probe.

20.10.6.2 Radiation Sources

CAM-1 depleted uranium check source. Nominally, 18,000 net cpm using portable gamma-scintillation detector.

20.10.6.3 Calibration Frequency

Primary laboratory calibration will be performed at least quarterly and immediately following any adjustment to or maintenance of the instrument. A field operation check is performed daily during use. Onsite cross-calibration of instrument readings with PIC exposure rate measurement is performed at each survey site.

20.10.6.4 Applicable Standards

ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration (for guidance only).

20.10.6.5 Calibration Procedure

Laboratory calibration

1. Notify ORNL EOSD that instrument is to be sent out for calibration and that a radiological survey and clearance for shipment of the instrument are requested.
2. Following the radiological survey, EOSD personnel will place a "green tag" (contamination tag, ORNL Form Number UN-14), on the instrument approving it for shipment to ORNL EOSD Standards Laboratory. If radioactive contamination exists, notify site leader who will arrange decontamination of the instrument.
3. Send instrument to ORNL EOSD Standards Laboratory for calibration.
4. Following calibration and on receipt of the instrument, verify the instrument identification and probe numbers and that EOSD Standards Laboratory has affixed a calibration tag to the instrument.

5. Notify the records technologist that the instrument has been calibrated. Supply the records technologist with the instrument number, date of calibration, and the EOSD Standards Laboratory calibration value (cpm) equal to 0.1 m/R radium.
6. Enter into the Instrument Calibration Log Book the instrument number, date of calibration, and the EOSD Standards Laboratory calibration value (cpm) equal to 0.1 m/R radium.

Field check

1. Check battery condition by setting range switch in BAT position and observing THYAC III meter. Indicator should be in Bat.Check region or battery replacement is mandatory. (See Instruction Manual for Model 490, THYAC III, and step 2, Sect. 6.9).
2. Set Response switch to MEDIUM position and the Range switch to appropriate position (maximum upscale deflection without going off scale).
3. Determine background level and record background cpm in the Instrument Calibration Log Book.
4. Place probe in contact with the CAM-1 depleted uranium check source and read gross cpm.
5. The net cpm reading must agree within Laboratory accepted limits (approximately ±20%) of the reading taken during the previous field check. (See System Adjustments, Sect. 6.8 of this procedure.)
6. If the reading obtained in step 5 is within the acceptable range, the instrument is now ready for use. If the reading is out of the acceptable range, change batteries and repeat steps 4 through 5. If reading is still out of acceptable range, return instrument to ORNL-RASA Laboratory for repair and recalibration according to Sect. 6.5.1 of this procedure.
7. Enter into the Portable Instrument Log Book the instrument number, source number, net cpm, date, and signature of instrument technologist.

Cross-Calibration with PIC

1. Set up PIC at an outdoor location according to Sect. 13.5, Gamma Exposure Rate Measurements (Pressurized Ion Chamber).
2. Perform PIC field check according to Sect. 20.9, Calibration of Pressurized Ion Chamber.
3. Hold portable gamma scintillator within 1 m of a side of the PIC detector and at a height of 1 m above the ground. Record gamma scintillator reading in cpm.
4. Repeat gamma scintillator readings for the remaining three sides of the PIC detector.
5. Record PIC reading in μR/h.
6. Average the 4 gamma scintillator readings.
7. Move PIC to several other locations (a minimum of 4) and repeat steps 3 through 6.
8. Record data on Field Data Form.
9. Repeat steps 1 through 8 for an indoor location.
10. Calculate cross-calibration factor for each location according to Sect. 6.6 of this procedure, Calculations.

20.10.6.6 Calculations

1. Net cpm = gross cpm - background cpm
2. Calculate cross-calibration factor for each measurement location using the formula

$$\text{cross-calibration factor} = \frac{A}{B} ,$$

where

A = PIC value (μR/h),
B = average gamma scintillator value (cpm).

20.10.6.7 Log Book Entries

Verify that all log book entries have been made in the appropriate log book in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.

Verify that the records technologist has been notified following laboratory calibration and that calibration data has been recorded.

20.10.6.8 System Adjustments

1. High voltage may be adjusted by the instrument technologist in the field. Record all adjustments in the Portable Instrument Log Book.

20.10.6.9 Special Notes and Instructions

1. Instrument may be calibrated to thorium or other source, instead of radium, upon request.
2. Replace batteries after every 24 h of use.

20.11 CALIBRATION OF PORTABLE GAMMA SPECTROMETRY SYSTEMS

20.11.1 Purpose

The purpose of this procedure is to provide a method for the field check of the portable gamma spectrometer.

20.11.2 Applicability

This procedure applies to the portable gamma spectrometer used in the RASA program.

20.11.3 References

1. ANSI N323-1978, Radiation Protection Instrument Test and Calibration (for guidance only)
2. Technical Manual for Geometrics Portable Gamma Ray Spectrometer Model GR-410
3. Sect. 16.3, Equipment Calibration Records

20.11.4 Definitions and Abbreviations

20.11.4.1 Definitions

LOG BOOK. At the ORNL-RASA Laboratory, the Instrument Calibration Log Book will be used for all calibration data and repair documentation. At a survey site, the Portable Instrument Log Book will be used for all calibration related field activities.

CALIBRATED INSTRUMENT FILE. Calibration records external to the log books maintained at the ORNL-RASA Laboratory by the records technologist.

Also see Sect. 1.5 of this manual, Terminology.

2.11.4.2 Abbreviations

cpm Counts per minute

I&C Instrumentation and Controls Division

EOSD Environmental and Occupational Safety Division

Also see Sect. 1.5 of this manual, Terminology.

20.11.5 Responsibilities

The instrument technologist is responsible for implementation of this procedure.

20.11.6 Procedure

20.11.6.1 Equipment and Supplies

Geometrics GR-410, Portable Scanning Gamma Ray Spectrometer

2.11.6.2 Radiation Sources

1. Co-60, Isotope Products Laboratories 14182.5 11.0 μCi (1-1-74) or equivalent
2. Cs-137, Isotope Products Laboratories 7286-5 12.0 μCi (11-1-79) or equivalent

20.11.6.3 Calibration Frequency

No laboratory calibration is performed. Instrument is used for qualitative measurements only. No field calibration is performed. Field check and system gain adjustment is performed before each use.

20.11.6.4 Applicable Standards

1. ANSI N323-1978, Radiation Protection Instrument Test and Calibration (for guidance only)

20.11.6.5 Calibration Procedure

Field check

Battery check. Check batteries by placing function selector switch in BT position. Observe that meter needle is within the green triangle band on the meter designated BATT. Replace batteries according to Battery Replacement Procedure 4.5 shown in Gamma Ray Spectrometer Technical Manual (see Sect. 6.9).

E Value potentiometers. Check E Value potentiometer dial settings and verify that they are in the following positions: Th=8.20; U=5.50; and K=4.60.

Display lamps. Test display lamps by placing function selector switch in BT position and press Read pushbutton (display should read 8888). If any element is not illuminated, send instrument to I&C Laboratory for repair per Sect. 6.5.2 of this procedure.

Active null.

1. Determine active null by placing function selector switch in GM position.
2. Set gain potentiometer to 0.00. The meter will be near mid-scale.
3. Rotate gain potentiometer clockwise. The meter needle will move away from its original position, either upscale or downscale.
4. The meter needle will suddenly move in the opposite direction towards the center scale of the meter, pass through center, and continue towards the opposite side. The meter will later return to its near mid-scale position as the potentiometer is rotated.
5. The active null is located between the maxima and minima observed during maximum excursions (positive and negative) from the meter mid-scale position.
6. Rotate gain potentiometer counter-clockwise until a maximum or minimum is obtained. Continue to rotate gain potentiometer until an active null is obtained (meter in center of green gain check "bow tie band" in center of meter scale).

Check source.

1. Determine cpm with function switch in TC position.
2. Place check source in contact with detector and determine gross cpm.
3. If net cpm differs from value obtained in the previous field check within Laboratory acceptance limits (approximately ±20%) the instrument is ready for use. If net cpm differs from value obtained in the previous field check, greater than Laboratory acceptance limits (approximately ±20%), send instrument to I&C Standards Laboratory for repair following Sect. 6.5.2 of this procedure.
4. Enter into Portable Instrument Calibration Log Book the date, net cpm, and signature of instrument technologist.

Instrument repair

1. Notify ORNL EOSD that instrument is to be sent out for repair and that a radiological survey and clearance for shipment of the instrument are requested.
2. Following the radiological survey, EOSD personnel will place a "green tag" (contamination tag, ORNL Form Number UCN-14), on the instrument approving it for shipment. If radioactive contamination exists, notify the laboratory technologist to arrange for the decontamination of the instrument.
3. Send instrument to ORNL I&C Standards Laboratory for repair.
4. Following repair and on receipt of the instrument, verify the instrument identification and probe numbers and that the repair facility has performed the required repairs to the instrument.
5. Perform instrument field check before placing instrument back in operation.

20.11.6.6 Calculation

$$\text{net cpm} = \text{gross cpm} - \text{background cpm}$$

20.11.6.7 Log Book Entries

Verify that all log book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.

20.11.6.8 System Adjustments

None.

20.11.6.9 Special Notes and Instructions

Replace batteries after every 24 h of use.

20.12 CALIBRATION OF LABORATORY GAMMA SPECTROMETRY SYSTEM

20.12.1 Purpose

The purpose of this procedure is to provide a method for the calibration of laboratory gamma spectrometry systems.

20.12.2 Applicability

This procedure applies to all standard laboratory gamma spectrometry systems used in the RASA program, including GeLi and Ge crystals as well as 5/11 and ND counting systems.

20.12.3 References

1. Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples
2. Sect. 16.3, Equipment Calibration Records
3. ANSI N42.14-1978, Calibration and Usage of Germanium Detectors for Measurement of Gamma Ray Emission Rates of Radionuclides (for guidance only)

20.12.4 Definitions and Abbreviations

20.12.4.1 Definitions

CALIBRATED INSTRUMENT FILE. Calibration records external to log books maintained at the ORNL-RASA Laboratory by the records technologist.

Also see Sect. 1.5 of this manual, Terminology.

20.12.4.2 Abbreviations

GeLi	Lithium drifted germanium detector
Ge	High purity germanium detector
5/11	Tennelec TP 5/11 Gamma Spectrometer System
ND	Nuclear Data Model 2400 Gamma Spectrometer System
ADC	Analog to Digital Converter

Also see Sect. 1.5 of this manual, Terminology.

20.12.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure, and the records technologist is responsible for maintaining retrievable calibration data and records as supplied by the instrument technologist.

20.12.6 Procedure

20.12.6.1 5/11 System Including GeLi and Ge Crystals

Energy calibration

Equipment and supplies. Equipment and supplies are specified in Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples.

Radiation sources. None. This procedure utilizes a current data file of soil spectra stored on disks, per data recording section, Determination of Radionuclides in Soil and Sediment Samples, Sect. 15.1.

Calibration frequency. Laboratory calibration is performed at two-week intervals or when system operation is suspect and immediately following maintenance or adjustment of the instrument. A field calibration is not performed.

Applicable standards.

ANSI N42.14-1978, Calibration and Usage of Germanium Detectors for Measurement of Gamma Ray Emission Rates of Radionuclides (for guidance only).

Calibration procedure.

1. This procedure rescales spectral span to coincide with established literature energy levels. Operation of the instrument, storage of data disks, etc., is included in Determination of Radionuclides in Soil and Sediment Samples, Sect. 15.1.
2. Control command symbol is shown as an arrow facing upward (e.g., ↑).
3. In the event of an error when entering information from console, console control of the system may be re-established at any time by entering ↑ C ↑ C G RETURN. This operation will cause previous data entered to be lost and the operator is required to initiate a new energy calibration.
4. The digit zero is shown as 0 and the alpha character as O.
5. Calibration values shown in this procedure are for carousel analysis. Well, Petri Dish, and Marinelli dewar sample holders require different values and are included as Exhibit 20.6.

Calculations. None.

Log book entries. None.

System adjustments. None.

Special notes and instructions. None.

20.12.6.2 ND System Including GeLi Crystal

Energy calibration

Equipment and supplies. Equipment and supplies specified by Determination of Radionuclides in Soil and Sediment Samples, Sect. 15.1.

Radiation sources. NBO5 New Brunswick Labs Soil Standard 441.5 g dated August 1975 and ^{88}Y stabilizer source.

Frequency of calibration. Laboratory calibrations are performed at two week intervals or when system operation is suspect and immediately following maintenance or adjustment of the instrument. No field calibrations are performed.

Applicable standards. ANSI N42-14-1978, Calibration and Usage of Germanium Detectors for Measurement of Gamma-Ray Emission Rates of Radionuclides (for guidance only).

Calibration procedure. This procedure will rescale the spectral span to coincide with established literature energy sample handling procedures included in Determination of Radionuclides in Soil and Sediment Samples, Sect. 15.1.

1. Install NBO5 Soil Standard in carousel holder and place in instrument per standard operating procedure.
2. Set digital spectrum analyzer gain to 1836 keV by flipping binary switches on GAIN side of analyzer panel to the left side. Flip 1024, 512, 256, 32, 8, and 4 (1 keV below 1837 keV peak for ^{88}Y).
3. Place RESET-ON-OFF switch in OFF position.
4. Press STOP/DISPLAY, both ERASE switches, and ACQUIRE switches on ND ADC.
5. Press calibrate button and check scope tracer as 1837 keV peak increases.
6. Adjust fine gain control on spectroscopic amplifier as necessary to have tracer on leading edge of peak, just before peak maximum.
7. Set right (zero) side of digital spectrum analyzer to 352 keV by flipping 256, 64, and 32 switches to left.
8. Place RESET-ON-OFF switch in OFF position.
9. Press STOP/DISPLAY, both ERASE switches, and ACQUIRE switches on ND ADC.
10. Press calibrate button on right (zero) side of stabilizer and check scope tracer as 352 keV peak increases.
11. Adjust Analog Zero to coincide with peak maximum.
12. Repeat steps 4 through 11 until no further adjustments are required to either the Fine Gain or Analog Zero controls.
13. Following standard operating procedures as stated in Determination of Radionuclides in Soil and Sediment Samples, Sect. 15.1, run NBO5 standard for 3600 seconds. Process data according to standard procedure.

Calculations. None.

Log book entries.

1. Verify that all log book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.
2. Verify that calibration values, date, and calibrator's name have been reported to the records technologist for inclusion in Calibrated Instrument File.

System adjustments. None.

Special notes and instructions. None.

Efficiency calibration

This procedure adjusts the computer programs as necessary to provide updated factors for the data calculations for this instrument (to be added as needed).

20.13 CALIBRATION OF GAMMA HOLE-LOGGING EQUIPMENT

20.13.1 Purpose

The purpose of this procedure is to provide a method for the field check of shielded and unshielded gamma hole-logging equipment.

20.13.2 Applicability

This procedure applies to all standard shielded and unshielded gamma hole-logging equipment used in the ORNL-RASA program.

20.13.3 References

1. Sect. 16.3, Equipment Calibration Records
2. Eberline Mini Scaler, Model MS-2 Technical Manual
3. ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration (for guidance only)

20.13.4 Definitions and Abbreviations

20.13.4.1 Definitions

LOG BOOK. At a survey site, the Drill Hole Logger Log Book will be used for all calibration related field activities. (One log book exists for each mobile laboratory.)

Also see Sect. 1.5 of this manual, Terminology.

20.13.4.2 Abbreviations

cpm Counts per minute

DPC Disintegrations per count

ANSI American National Standards Institute

EOSD Environmental and Occupational Safety Division

20.13.5 Responsibilities

The instrument technologist is responsible for implementing this procedure, and the records technologist is responsible for maintaining retrievable calibration data and records as supplied by the instrument technologist.

20.13.6 Procedure

20.13.6.1 Equipment and Supplies

Eberline Model MS-2 Mini Scaler and shielded or unshielded gamma hole-logging probes.

20.13.6.2 Radiation Sources

Depleted uranium CAM-1 check source. Nominally 18,000 net cpm using Victoreen Thyac III Gamma-Scintillation Survey Meter.

20.13.6.3 Calibration Frequency

No laboratory calibration is performed; instrument is used for comparative purposes only. No field calibration is performed; field operational check is performed at least daily before use.

20.13.6.4 Applicable Standards

ANSI N323-1978, Radiation Protection Instrumentation Test and Calibration (for guidance only).

20.13.6.5 Calibration Procedure

Field check

1. Check Batteries. Following the Eberline Model MS-2 Mini Scaler Technical Manual procedures, check battery condition using External Volt Meter (see Sect. 6.9), if unit is to be run on battery power.
2. Set response time control at midpoint of its rotation.
3. Set TEST switch to ON position.

4. Set TIMED-STOP-MAN. switch to "MAN." Units should begin to count.
5. Set TIMED-STOP-MAN. switch to TIMED position.
6. Set Count Time in Minutes switches to 1 and X0.1.
7. Press START-RESET switch.
8. Unit should count for 6 s and display 356-360 counts.
9. Set Count Time in Minutes switches to 1 and X1.
10. Press START-RESET switch.
11. Unit should count for 60 s and display 3580-3600 counts.
12. If unit fails either the 6 s or 60 s test, send instrument to EOSD Standards Laboratory.
13. Set Count Time in Minutes switches to 1 and X1.
14. Press START-RESET switch.
15. After counting stops (1 min), record background count value in Drill Hole Logger Log Book.
16. Place probe in contact with the depleted uranium CAM-1 check source.
17. Press START-RESET switch.
18. After counting interval (1 min) record source count in Drill Hole Logger Log Book.
19. Repeat Steps 18 and 19.
20. If the values determined in Steps 18 and 19 differ by >±10%, send instrument to EOSD Standards Laboratory.
21. Net cpm must agree within Laboratory accepted limits (approximately ±20%) of the reading taken during the previous field check. (See System Adjustments, Sect. 6.8.)
22. If the net counts are within the acceptable range, the instrument is now ready for use. If the reading is out of the acceptable range, do not use instrument. Send the instrument to EOSD Standards Laboratory.
23. Enter into the Drill Hole Logger Log Book the instrument number, source number, net counts, date, and signature of instrument technologist.

20.13.6.6 Calculations

net cpm = gross cpm - background cpm

20.13.6.7 Log Book Entries

Verify that all log book entries have been made in the appropriate log book in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.

Verify that the records technologist has been notified following laboratory calibration and that calibration data has been recorded.

20.13.6.8 System Adjustments

High voltage may be adjusted by instrument technologist in the field. Adjustments should be documented in the Drill Hole Logger Log Book.

20.13.6.9 Special Notes and Instructions

Recharge batteries every 24 h of use or when battery voltage is below 7.5 vdc at 1 amp. Replace batteries if they will not recharge.

20.14 CALIBRATION OF WRENN CHAMBERS

20.14.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration of Wrenn Chambers

20.14.2 Applicability

This procedure applies to all standard Wrenn Chambers used in the ORNL-RASA program.

20.14.3 References

1. Sect. 13.9, Radon Measurements
2. Sect. 16.3, Equipment Calibration Records
3. Sect. 20.16, Calibration of Lucas and ORNL Cells

20.14.4 Definitions and Abbreviations

20.14.4.1 Definitions

CALIBRATED INSTRUMENT FILE. Master file of calibration factors, etc.

LOG BOOK. Wrenn Chamber Calibration Log Book maintained at the RASA Laboratories. Each of the counting systems (electronics unit and two associated Wrenn Chambers) has its own log book.

Also see Sect. 1.5 of this manual, Terminology.

20.14.4.2 Abbreviations

pCi/L Picocuries per liter

cpm Counts per minute

Also see Sect. 1.5 of this manual, Terminology.

20.14.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure, and the records technologist is responsible for maintaining calibration data, supplied by the instrument technologist, in the Calibrated Instrument File.

20.14.6 Procedure

20.14.6.1 Equipment and Supplies

1. ORNL Wrenn Chamber calibration cabinet, material and equipment specified in Radon Measurements, Sect. 13.9 (for both Wrenn Chambers and Lucas cells)
2. Lucas cells calibrated according to Calibration of Lucas and ORNL cells, Sect. 20.16
3. One cylinder (220 standard ft^3 minimum) of aged (minimum 30 days) compressed air
4. ^{239}Pu field check source
5. Duct seal tape

20.14.6.2 Radiation Sources

1. ^{222}Ra provided by uranium ore in sealed 55 gallon drum. Quantification of radon source concentration is provided by Lucas Cell sampling and measurements.
2. ^{239}Pu on brass rod check source.

20.14.6.3 Calibration Frequency

Laboratory calibration is performed less than two weeks before extended field use and a minimum of once annually. (See Sect. 6.9 of this procedure). Field calibration is performed immediately following field set up of equipment. Field check for counting system.

20.14.6.4 Applicable Standards

None.

20.14.6.5 Calibration Procedure

Laboratory calibration (Wrenn Chamber)

1. Connect Wrenn Chamber to calibration cabinet air manifold, seal chamber in a common plastic refuse bag and seal cable ports in side of chamber with duct seal tape (between one and six chambers may be accommodated by the calibration apparatus). Refer to Wrenn Chamber Calibration Apparatus, Exhibit 20.8.
2. Purge Wrenn Chambers with aged (stored for minimum of 30 days) air over a period of 48 h. Set air regulator to sustain a minimum flow of approximately 18 ft^3/day/chamber (20% regulator setting for six chambers).
3. Record Wrenn Chamber counter instrument control settings in Wrenn Chamber Calibration Log Book.

4. Following Radon Measurements, Sect. 13.9, (for Wrenn Chambers), determine average background count rate for each chamber over a minimum period of 24 h and record in Wrenn Chamber Calibration Log Book. A series of 16-30 1 h intervals are used in determining the average background.
5. Remove bag(s) from Wrenn Chamber(s), disconnect chamber(s) from air manifold, and insert stopper(s) in chamber orifice(s).
6. Close calibration cabinet door and seal with plastic tape as illustrated in Wrenn Chamber Calibration Apparatus, Exhibit 20.8.
7. Open upper and low radon transfer line valves between cabinet and radon source drum as illustrated in Wrenn Chamber Calibration Apparatus, Exhibit 20.8.
8. Transfer radon to calibration cabinet using 50 strokes of transfer pump (approximately 450 mL/stroke) as illustrated in Wrenn Chamber Calibration Apparatus, Exhibit 20.8.
9. Close upper and lower transfer line valves and switch on cabinet circulation fan for 15 min as illustrated in Wrenn Chamber Calibration Apparatus, Exhibit 20.8.
10. Wait 12 hours for radon equilibrium in cabinet to occur.
11. Begin measurement of humidity inside calibration cabinet, using internal sensor with remote monitor and readout. (See Sect. 6.9 of this procedure.)
12. Following Radon Measurements, Sect. 13.9 (for Wrenn Chamber counter operation), begin 60 min counting interval for each chamber. Three successive 1 h counting intervals will be used as the calibration interval.
13. Midway through the calibration interval attach a Lucas cell to the cabinet at the exhaust port as illustrated in Wrenn Chamber Calibration Apparatus, Exhibit 20.15-1, and withdraw sample into the Lucas cell (fill 4 cells).
14. Record in Wrenn Chamber Calibration Log Book the counts for each Wrenn Chamber at the end of each calibration interval, noting the length of this interval (normally 3 h).
15. Following Radon Measurements, Sect. 13.9 (for Lucas cell operation), determine the concentration of radon in each Lucas cell used in Sect. 6.5.1, step 13, and record in Wrenn Chamber Calibration Log Book.
16. Repeat steps 11-15 at two different humidity levels (minimum change of 20% relative humidity). Humidity is established by ambient atmospheric conditions, and cannot be controlled. Therefore, these steps must be completed after atmospheric conditions have changed sufficiently to achieve the required humidity difference.
17. Purge Wrenn cell calibration cabinet by opening after a minimum of 24 h.

Field check (counting system)

1. Following Radon Measurements, Sect. 13.9 (for Wrenn Chamber System operation), determine background for a counting interval of 10 min. Record background count rate (cpm) in Wrenn Chamber Calibration Log Book.

2. Install ^{239}Pu check source in detector assembly and count for an interval of 10 min. Record gross count rate (cpm) in Wrenn Chamber Calibration Log Book.
3. If the net counts (gross counts minus background counts) are within ±20% of the previously determined value, the system is considered to be within the calibration limits.
4. If the net counts exceed the ±20% criteria described in step 3, adjust the high voltage and/or amplifier gain to alter the detector response to within the ±20% constraint, and then consider the system to be within the calibration limits.
5. If unable to bring the system within calibration limits, notify the instrument technologist responsible for maintenance and repair of instrumentation.

20.14.6.6 Calculations

1. Obtain average pCi/L values for Lucas cell determinations (Sect. 6.5.1, step 13 of this procedure) at each humidity level.
2. Calculate Wrenn Chamber conversion factor at each humidity level using the formula

Wrenn Chamber Conversion Factor (cpm/pCi/L)

$$= \frac{\frac{WCC}{WCI} - \frac{WBC}{BCI}}{ALC},$$

where

WCC = Wrenn Chamber counts (Sect. 6.5.1, step 14 of this procedure),
WCI = Wrenn Chamber counting interval in minutes (Sect. 6.5.1, step 12 of this procedure),
WBC = background counts (Sect. 6.5.1, step 4 of this procedure),
BCI = background counting interval in minutes (Sect. 6.5.1, step 4 of this procedure),
ALC = average radon concentration in calibration chamber determined from measurements (pCi/L) (Sect. 6.5.1, step 15).

20.14.6.7 Log Book Entries

1. Verify that all Wrenn Chamber Calibration Log Book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3. Since one Wrenn Chamber Calibration Log Book exists for two chamber units, verify that the log book used coincides with the counting system used during calibration. Log book entries include the following data: date of most recent calibration, signature of calibrator, Wrenn Chamber identification number, Wrenn Chamber conversion factor for each measured humidity level (Sect. 6.6, step 2 of this procedure), unusual or special use conditions, and date of next required calibration.

2. Enter all maintenance or repair operations performed on Wrenn Chamber into the Wrenn Chamber Calibration Log Book including: date, signature of repair/maintenance person, and nature of work performed.
3. Attach a calibration sticker to the Wrenn Chamber. Since operation of the Wrenn Chamber system requires frequent use of the log book containing calibration data, the calibration sticker contains only the calibration date but may also contain calibration factors as a matter of convenience.
4. Report Wrenn Chamber identification number, calibration date, current calibration factor(s) and corresponding humidity levels to records technologist for inclusion in Calibrated Instrument File.

20.14.6.8 System Adjustments

None.

20.14.6.9 Special Notes and Instructions

1. Wrenn Chamber must be recalibrated immediately following any repair or maintenance to the chamber or counter system.
2. The humidity measurement system should be calibrated at least annually.

20.15 CALIBRATION OF LUCAS AND ORNL CELLS

20.15.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration of ORNL and Lucas cells.

20.15.2 Applicability

This procedure applies to all ORNL and Lucas cells used in the ORNL-RASA program.

20.15.3 References

1. Sect. 13.9, Radon Measurements
2. Sect. 16.3, Equipment Calibration Records
3. ASTM-D3454-79 (for guidance only)

20.15.4 Definitions and Abbreviations

20.15.4.1 Definitions

BACKGROUND COUNTS. Total number of counts resulting from naturally occurring radiation in system environment and system noise.

EMANATION. Gaseous release from a source. Radon emanation refers to the release of ^{222}Ra from a ^{226}Ra source.

GROSS COUNTS. Total number of counts resulting from sample being counted, naturally occurring radiation in system environment, and system noise.

LOG BOOK. Lucas and ORNL Cell Calibration Log Book maintained at the ORNL-RASA laboratory.

MICRONS. Unit of length equal to 10^{-6} m. When applied to pressure measurements a micron represents the height of a mercury column that can be supported by the applied pressure.

NET COUNTS. Total number of counts resulting from sample being counted (gross counts - background counts).

Also see Sect. 1.5 of this manual, Terminology.

20.15.4.2 Abbreviations

ASTM	American Society for Testing Materials
cpm	Counts per minute
ft^3	Cubic foot
L	Liter
mL	Milliliter ($\frac{1}{1000}$ Liter)
NBS	National Bureau of Standards
pCi/L	Picocuries per liter

Also see Sect. 1.5 of this manual, Terminology.

20.14.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure, and the records technologist is responsible for maintaining calibration data, supplied by the instrument technologist, in the Calibrated Instrument File.

20.15.6 Procedure

20.15.6.1 ORNL Chambers

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Equipment and supplies

1. ORNL de-emanation apparatus for ORNL cells
2. Materials and equipment specified in Radon Measurements, Sect. 13.9, for ORNL cells including ORNL cells and ORNL cell counting system
3. One cylinder (220 ft^3) of aged (minimum 30 days) compressed air
4. 10 mL pipette
5. Fume hood
6. Vacuum pump capable of achieving <50 microns pressure and containing a manometer capable of low pressure measurements (<25 microns).

Radiation sources

^{226}Ra NBS traceable standard (NBS-4955) (0.10 microgram ±3.6%) obtained in solution, 5 mL quantity, 5% HNO_3 by weight (see Sect. 6.1.9 of this procedure).

Calibration frequency

Laboratory calibration is performed a minimum of semi-annually and immediately following maintenance and repair, or when defective operation is suspected in either the chamber or counter system. No field calibration is performed.

Applicable standards

ASTM-D3454-79 (for guidance only).

Calibration procedure

1. Set up de-emanation apparatus according to ORNL De-emanation Apparatus in a fume hood. (NOTE: Check stopcocks for lubrication. Grease if necessary.)
2. Evacuate ORNL Cell to a pressure <50 microns by connecting cell to a vacuum pump (with manometer), opening cell valve, and turning pump on until a pressure <50 microns is achieved. Close cell valve, turn off pump, and disconnect cell.
3. Perform counter system test according to Sect. 6.3 of this procedure.
4. Place evacuated ORNL cell in in ORNL/Lucas cell counter system and perform 10-min count to determine background according to Radon Measurements, Sect. 13.9.
5. Record background counts in ORNL and Lucas Cell Calibration Log Book.
6. Connect emanation tube to apparatus as illustrated in ORNL Cell De-emanation Apparatus. Connect evacuated ORNL chamber to apparatus.

7. Close stopcock #2, open stopcock #1 (both shown closed in Exhibit 20.9), place 2-way stopcock #3 in position A. (See Exhibit 20.9 for stopcock identification and position.)
8. Open ORNL Cell valve.
9. Apply air pressure of 2 in. water as measured on pressure gauge calibrated in inches of water as illustrated in ORNL De-emanation Apparatus.
10. Slowly open stopcock #2 to allow flow through emanation tube. Care must be exercised to prevent vigorous flow, or solution would bubble out of emanation tube into the stopcock.
11. De-emanate for a minimum of 5 min resulting in at least 10 emanation tube volumes passing through the system (approximately 250 mL).
12. Close stopcock #2 and #1 and place stopcock #3 in position B. (See ORNL Cell De-emanation Apparatus).
13. Allow de-emanation apparatus pressure to build to equivalent 1/2 in. of water, monitoring system pressure on air pressure gauge calibrated in inches of water.
14. Close ORNL cell valve, turn off air supply, and disconnect ORNL cell from system. Record beginning of decay time in ORNL and Lucas Cell Calibration Log Book.
15. Allow radon in the ORNL Cell to equilibrate for 4 h.
16. Disconnect emanation tube from system and place in storage for at least 30 days before next use. Change date on white paper tag attached to emanation tube to the current date.
17. After 4-h equilibration time, place ORNL cell in ORNL/Lucas cell counter, and following Radon Measurements, Sect. 13.9 (for ORNL cells), determine ORNL cell counts for a 10-min counting interval. Record gross counts, time at midpoint of counting interval, and counting interval time in ORNL and Lucas Cell Calibration Log Book.
18. Calculate ORNL Cell conversion factor following Sect. 6.1.6 of this procedure.
19. Attach a calibration sticker to the ORNL cell including the cell number, calibration date, and conversion factor. Notify the records technologist that calibrations have been completed and supply the records technologist with calibration data for inclusion in the Calibrated Instrument File.
20. Enter information from Item 19 into ORNL and Lucas Cell Calibration Log Book and sign.
21. Repeat Sect. 6.1.5 (except step 3) for each ORNL cell to be calibrated.

Calculations

1. Correct counts determined in step 18 of Sect. 6.1.5 for decay using the equation

$$\frac{A}{T} = A_o e^{-\lambda t} ,$$

Solving for A_o:

$$A_o = \frac{A}{Te^{-\lambda t}} ,$$

where

A_o = decay corrected counts per minute (cpm),
A = Measured net counts (gross - background as determined in Sect. 6.1.5, step 4 and 17),
T = counting interval (in minutes),
λ = decay constant for ^{222}Ra (1.1238/min),
t = time from de-emanation to midpoint of counting interval (minutes).

2. Determine conversion factor using the formula

ORNL Cell,

$$\text{Conversion factor} = \frac{\frac{A_o}{1000 \text{ pCi}}}{500 \times 10^{-3} \text{l}} ,$$

(cpm/pCi/L).

Log book entries

Verify that all ORNL and Lucas Cell Calibration Log Book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.

System adjustments

None.

Special notes and instructions

1. ^{226}Ra standard reference solution is diluted to 1000 mL total volume in 3% HNO_3 by the ORNL Chemistry Technology Laboratory. The concentration of this dilution is 100 pCi/mL.
2. Emanation source is prepared by pipetting 10 mL of 100 pCi/mL solution into emanation tube illustrated in Emanation Tube, Exhibit 20.16-2. Close both stopcocks and allow source to reach equilibrium (minimum 30 days). Attach a white paper tag to emanation tube. Record on it the assigned emanation tube number and date.

20.15.6.2 Lucas Cells

Equipment and supplies

1. ORNL de-emanation apparatus for Lucas cells
2. Materials and equipment specified in Radon Measurements, Sect. 13.9, for Lucas cells including Lucas cells and Lucas cell counting system
3. One cylinder (220 ft^3) of aged (minimum 30 days) compressed air
4. 10 mL pipette
5. Fume hood
6. Vacuum pump capable of achieving <50 microns pressure and containing a manometer capable of low pressure measurements (<25 microns)

Radiation sources

^{226}Ra NBS traceable standard (NBS-4955) (0.10 microgram ±3.6%) obtained in solution, 5 mL quantity, 5% HNO_3 by weight. (See Sect. 6.2.9 of this procedure.)

Calibration frequency

Laboratory calibration is performed a minimum of semi-annually and immediately following maintenance and repair, or when defective operation is suspected in either the cell or counter system. No field calibration is performed.

Applicable standards

ASTM D-3454-79 (for guidance only).

Calibration procedure

1. Set up de-emanation apparatus according to Lucas Cell De-emanation Apparatus in a fume hood. (Note: Check stopcocks for lubrication and grease if necessary.)
2. Attach Lucas cell to apparatus.
3. Close Stopcocks #1 and #2, place stopcock #3 in position A and open Lucas cell stopcock.
4. Switch on vacuum pump and evacuate Lucas cell and associated tubing to a pressure of <50 microns.
5. Close Lucas Cell stopcock, place stopcock #3 in position B, and switch off vacuum pump.
6. Perform counting system test according to Sect. 6.3 of this procedure.
7. Place Lucas cell in ORNL/LUCAS cell counting system and perform 10-min background count.

8. Record background count in ORNL and Lucas Cell Calibration Log Book.
9. Remove Lucas Cell from counting system and place on Lucas Cell de-emanation apparatus.
10. Place stopcock #3 in position A and switch on vacuum pump.
11. Evacuate Lucas Cell de-emanation apparatus associated tubing to a pressure <50 microns.
12. Place stopcock #3 in position B, switch off vacuum pump, and open Lucas cell stopcock.
13. Apply air pressure of 2 in. water and open stopcock #1, (as measured on pressure gauge calibrated in inches of water) as illustrated in Lucas Cell De-emanation Apparatus.
14. Slowly open stopcock #2 to allow flow through emanation tube. Care must be exercised to prevent vigorous flow, or solution would bubble out of emanation tube into the stopcock and Lucas cell.
15. De-emanate to allow a minimum of approximately 4 emanation tube volumes (100 mL) through the system (approximately 5-min).
16. Allow Lucas cell de-emanation apparatus pressure to approach atmospheric (over a period of 2-5 min) by monitoring the differential liquid levels in the inlet and outlet sides of the emanation tube. When the differential level between the emanation tube arms reaches 2 in., close Lucas cell stopcock.
17. Turn off air supply and disconnect Lucas cell from system. Record time in ORNL and Lucas Cell Calibration Log Book.
18. Allow radon in Lucas cell to equilibrate for 4 h.
19. After de-emanation apparatus pressure reaches atmospheric pressure, as measured on 2 in. water pressure gauge, close stopcocks #1 and #2, disconnect emanation tube from system, and place in storage for at least 30 days before next use. Change date on white paper tag attached to emanation tube to current date.
20. After 4-h equilibration time, place Lucas Cell in ORNL/Lucas cell counter and according to Radon Measurements, Sect. 13.9, for Lucas cells, determine Lucas cell counts for a 10-min counting interval. Record gross counts, time at midpoint of counting interval, and counting interval in ORNL and Lucas Cell Calibration Log Book.
21. Calculate Lucas Cell conversion factor following Sect. 6.2.6 of this procedure.
22. Attach a calibration sticker to the Lucas Cell including the cell number, calibration date, and conversion factor. Notify the records technologist that calibrations have been completed and supply the records technologist with calibration data for inclusion in the Calibrated Instrument File.
23. Enter information from step 21 of this section into the ORNL and Lucas Cell Calibration Log Book and sign.
24. Repeat Sect. 6.2.5 (except step 6) for each Lucas cell to be calibrated.

Calculations

$$\frac{A}{T} = A_o e^{-\lambda t} ,$$

Solving for A_o:

$$A_o = \frac{A}{Te^{-\lambda t}} ,$$

where

A_o = decay corrected counts per minute (cpm),
A = measured net counts (gross - background),
T = counting interval (min),
λ = decay constant for ^{222}Ra (1.1238/min),
t = time from de-emanation to midpoint of counting interval (min).

Determine conversion factor using the formula

$$\text{Lucas cell conversion factor (pCi/L/cpm)} = \frac{\frac{1000 \text{ pCi}}{95 \times 10^{-3} \text{ l}}}{A_o}$$

Log book entries

Verify that all log book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 15.3.

System adjustments

None.

Special notes and instructions

1. ^{226}Ra standard reference solution is diluted to 1000 mL total volume for 3% HNO_3 by the ORNL Chemistry Technology Laboratory. The concentration of this dilution is 100 pCi/mL.
2. Emanation source is prepared by pipetting 10 mL of 100 pCi/mL solution into emanation tube as illustrated in Emanation Tube, Exhibit 20.9. Close both stopcocks and allow source to reach equilibrium (minimum 30 days). Attach a white paper tag to emanation tube. Record on it the assigned emanation tube number and date.

20.15.6.3 ORNL/Lucas Cell Counter System Test

Equipment and supplies

Materials and equipment specified in Radon Measurements, Sect. 13.9, for ORNL and Lucas cells, including ORNL cell counting system.

Radiation sources

Check source consisting of ^{241}Am disc source contained in a brass container with ZnS cover on plate glass bottom (same diameter as Lucas cell). Source strength determined by ORNL Analytical Chemistry Division on calibrated system.

Calibration frequency

Calibration is performed before each use of counter system.

Applicable standards

None.

Calibration (system test) procedure

1. Following Radon Measurements, Sect. 13.9, for ORNL and Lucas cells, determine system background over a 10-min time interval and record in log book. (See Sect. 6.3.7, step 1.)
2. Install ^{241}Am canister check source in either the ORNL or Lucas Cell detector assemblies as appropriate.
3. Determine the alpha count over a 10-min time interval.
4. Record gross counts, time interval and instrument settings in the appropriate log book. (See Sect. 6.3.7, step 1.)

Calculations

Determine system operational status using the following formula to check efficiency

$$E = \frac{\frac{A}{T}}{A_o},$$

where

E = system efficiency
A = measured net counts (gross - background) (Sect. 6.3.5, steps 1 and 3)
T = counting interval (min)
A_o = source strength (cpm)

Log book entries

1. For laboratory based systems, use the Instrument Calibration Log Book. For mobile laboratory based systems, use either the ORNL or Lucas Cell Log Books for the appropriate mobile laboratory.
2. Verify that the log book used is in accordance with Sect. 6.3.7, step 1.
3. Verify that all log book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 15.3.

System adjustments

1. If the system efficiency (Sect. 6.3.6) does not fall between 0.9 and 1.1, proceed as follows: call authorized ORNL-RASA Instrument Service personnel to re-adjust linear amplifier gain and/or high voltage, using an oscilloscope, to put 10% of pulses in linear amplifier overload region, and repeat counter system test.
2. Following re-adjustment of the equipment, the authorized ORNL-RASA Instrument Service person shall enter into the ORNL and Lucas Counter System Log Book the following information: date, details of operations performed including "as found" and "as left" information, and signing off the entry.

Special notes and instructions

None.

20.16 CALIBRATION OF CHARCOAL CANISTERS

20.16.1 Purpose

The purpose of this procedure is to provide a method for the calibration of charcoal canisters.

20.16.2 Applicability

This procedure applies to all standard charcoal canisters utilized in the ORNL-RASA program.

20.16.3 References

1. Sect. 13.8, Onsite Gamma Spectrometry
2. Sect. 16.3, Equipment Calibration Records
3. Sect. 20.6, Calibration of Onsite Gamma Spectrometers
4. Nuclear Data ND 100 Pulse Height Analyzer Technical Manual
5. Tracor Northern TN 1314 Display Unit Technical Manual
6. Tracor Northern TN 1706 Pulse Height Analyzer Technical Manual
7. ORTEC 490B Linear Amplifier Technical Manual
8. ORTEC 456 High Voltage Power Supply Technical Manual
9. Tennelec Tennebin 3 Nimbin Power Supply Technical Manual

20.16.4 Definitions and Abbreviations

20.16.4.1 Definitions

EMANATION. Gaseous release from a source. Radon emanation refers to the release of ^{222}Ra from a ^{226}Ra source.

BACKGROUND COUNTS. Total number of counts resulting from naturally occurring radiation in system environment and system noise.

GROSS COUNTS. Total number of counts resulting from sample being counted, naturally occurring radiation in system environment, and system noise.

LOG BOOK. Adam system and Eve system log books maintained with the counting systems.

NET COUNTS. Total number of counts resulting from sample being counted (gross counts - background counts).

20.16.4.2 Abbreviations

cpm	Counts per minute
pCi/L	Picocuries per liter
mL	Milliliter ($\frac{1}{1000}$ Liter)
L	Liter
ASTM	American Society for Testing Materials
ft<3>	Cubic foot
NBS	National Bureau of Standards

Also see Sect. 1.5 of this manual, Terminology.

20.15.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure, and the records technologist is responsible for maintaining calibration data, supplied by the instrument technologist, in the Calibrated Instrument File.

20.16.6 Procedure

20.16.6.1 Equipment and Supplies

1. General purpose radon de-emanation apparatus with charcoal canister adapter
2. Oven capable of sustained 110°C operation
3. Adam or Eve Mobile Gamma Spectrometer as specified in Onsite Gamma Spectrometry, Sect. 13.8
4. One cylinder of compressed breathing quality air aged for a minimum of 30 days
5. Fume hood
6. Clock

20.16.6.2 Radiation Sources

^{226}Ra NBS traceable standard (NBS-4955) (0.10 microgram ±3.6%) obtained in solution, 5 mL quantity, 5% HNO_3 by weight.

20.16.6.3 Calibration Frequency

Laboratory calibration is performed a minimum of quarterly and immediately following maintenance and repair, or when defective operation is suspected in either the canister or counter system. There is no fixed time frequency for field calibration; it is determined by usage and needs.

20.16.6.4 Applicable Standards

None.

20.16.6.5 Calibration Procedure

1. Set up de-emanation apparatus in a fume hood. (Note: check stopcocks for lubrication. Grease if necessary.)
2. Pipette 10 mL of ^{226}Ra solution into emanation tube (see Exhibit 20.9), close both stopcocks, and allow emanation to reach equilibrium (minimum 30 days). Place date on plain white cardboard tag along with an assigned emanation tube number and attach to emanation tube.
3. Connect emanation tube to apparatus (see Exhibit 20.9).
4. Place canisters to be calibrated in oven at 110°C for 12 h. Maintain low (approximately 100 mL/min) air flow into oven.
5. Turn off oven, allow canisters to cool to room temperature, and double bag in sealed plastic bags.
6. Remove canister from plastic bag, remove metal screw cap from canister, and connect canister to de-emanation apparatus as illustrated in General Purpose Radon De-emanation Apparatus.
7. Open stopcocks #1 and #2, place 3-way stopcock #3 in position A as shown in Exhibit 20.9.
8. Set air flow rate by adjusting inlet pressure to 2 in. water as measured on Magna Helic Manometer. For field calibration, the air supply system consists of a rubber bulb, which, when compressed, produces air flow through the apparatus.
9. Note time of air flow start and record in Adam or Eve Log Book.
10. De-emanate for 10 min at approximately 1 L/min and close stopcock #1 and stopcock #2.
11. Turn off air supply and place stopcock #3 in position B.
12. Remove charcoal canister from de-emanation apparatus, replace metal canister screw cap, and reseal in plastic bag immediately. Allow to equilibrate for 4-h total elapsed time since start of air flow.
13. Disconnect emanation tube from system and place in storage for at least 30 days before next use. Change date on white cardboard tag attached to emanation tube to current date.

14. Perform counting system calibration following Calibration of Onsite Gamma Spectrometers, Sect. 20.6.
15. Perform background count for a period of 10 min using the two regions (channels 287-519 and 709-848) of interest.
16. After 4-h equilibration, place canister in Adam or Eve mobile gamma spectrometer and accumulate counts for a period of 10 min using the two regions (channels 287-519 and 709-848) of interest.
17. Calculate charcoal canister conversion factor following Calculations, Sect. 6.6 of this procedure.
18. Attach a calibration stick to canister including date, canister number, canister conversion factor and signature.
19. Enter information from step 17 into log book.
20. Report canister number, calibration date, and canister conversion factor to the records technologist for inclusion in Calibrated Instrument File.

20.16.6.6 Calculations

Determine net counts using the following equation:

$$(B-a) + (C-b) = A ,$$

where

B = gross sample counts (287-519 window),
a = background counts (287-519 window),
C = gross sample counts (709-848 window),
b = background counts (709-848 window),
A = net counts.

Correct counts determined in step 1 of this section for decay, using the equation

$$\frac{A}{T} = A_o e^{-\lambda t} ,$$

Solving for A_o:

$$A_o = \frac{A}{Te^{-\lambda t}} ,$$

where

A_o = decay correct net counts per minute (cpm),
A = measured net counts (gross - background),
T = counting interval (in minutes),
λ = decay constant for ^{222}Ra (1.1238/min),
t = Time from de-emanation to midpoint of counting interval (minutes).

Determine charcoal canister conversion factor using the equation

$$\frac{A_o}{1000} = E,$$

where

A_o = decay correct net cpm (from equation 2),
E = charcoal canister conversion factor (pCi/cpm).

Calibration equations are also programmed into the PET computer system and may be used to facilitate the calculations.

20.16.6.7 Log Book Entries

1. Verify that all log book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 15.3.
2. Enter all maintenance or repair operations performed on the charcoal canisters or counting system into Adam or Eve Log Book.
3. Report charcoal canister identification number, conversion factor, and date to the records technologist for inclusion in the Calibrated Instrument File.

20.16.6.8 System Adjustments

None.

20.16.6.9 Special Notes and Instructions

None.

20.17 CALIBRATION OF AIR PUMPS

20.17.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration of low volume air pumps.

20.17.2 Applicability

This procedure applies to all standard low volume air pumps used in the ORNL-RASA program. High volume air pumps are used qualitatively and are not calibrated.

20.17.3 References

1. Sect. 16.3, Equipment Calibration Records
2. Sect. 20.20, Calibration of Wet Test Meters

20.17.4 Definitions and Abbreviations

20.17.4.1 Definitions

LOG BOOK. Air Pump and Mass Flow Meter Calibration Log Book at the ORNL-RASA laboratory.

Also see Sect. 1.5 of this manual, Terminology.

20.17.4.2 Abbreviations

I&C Instrumentation and Controls Division

%V Percent variation

Δp Differential pressure gauge

^{o}C Degrees Celsius

Also see Sect. 1.5 of this manual, Terminology.

20.17.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure, and the records technologist is responsible for maintaining calibration data, supplied by the instrument technologist, in the Calibrated Instrument File.

20.17.6 Procedure

20.17.6.1 Equipment and Supplies

1. Low volume air pump system (Radeco Pump, Matheson 8160 mass flow indicator, vacuum pump and gauges)
2. 0.45 μm, 25 mm diameter membrane filters
3. American Meter Company A1-19 wet test meter with thermometer
4. Stopwatch

20.17.6.2 Radiation Sources

None.

20.17.6.3 Calibration Frequency

Laboratory calibration is performed at least annually, and immediately following maintenance and repair, or when defective operation is suspected. No field calibration is performed.

20.17.6.4 Applicable Standards

Wet test meter is calibrated according to Calibration of Wet Test Meters, Sect. 20.20.

20.17.6.5 Calibration Procedure

1. Check bubble level indicator on wet test meter and adjust stand height if necessary to level instrument.
2. Check water level on wet test meter and add water if necessary to bring pin in water chamber just in contact with the surface of the water.
3. Place new membrane filter (Gelman Acropor #61256 or equivalent) in filter holder, and record product and batch number in Air Pump and Mass Flow Meter Calibration Log Book.
4. Connect pump system inlet to wet test meter outlet. See Low Volume Air Pump Apparatus Schematic, Exhibit 20.10.
5. Zero all gauges on the wet test meter.
6. Record temperature in degrees Celsius (^{o}C) from wet test meter thermometer in Air Pump and Mass Flow Meter Calibration Log Book.
7. Switch on low volume air pump system and simultaneously start stopwatch.
8. At 2 min, record mass flow meter reading, Δp, and pump head vacuum in the Air Pump and Mass Flow Meter Calibration Log Book.
9. At 9 min, record mass flow meter reading, Δp, and pump head vacuum in the Air Pump and Mass Flow Meter Calibration Log Book.
10. At 10 min stop pump system.
11. Record wet test meter volume in the Air Pump and Mass Flow Meter Calibration Log Book.
12. If mass flow meter readings at 2 and 9 min differed by >5%, replace filter and rerun test.
13. Repeat steps 5-12 two more times.
14. Proceed with calculations as shown in Sect. 6.6. Average the three variations (%V).
15. Enter into the Air Pump and Mass Flow Meter Log Book date of calibration, calibrator's name, average %V, date of next required calibration, instrument identification number, and any special use conditions of equipment.
16. Report equipment identification number, calibration date, and percent variation (%V) to records technologist for inclusion in Calibrated Instrument File.

20.17.6.6 Calculations

For each of the three tests, evaluate the percent variation using the formula

$$\%V = \frac{\frac{M}{W}}{10} \times 100,$$

where

%V = percent variation,
M = mass flow meter reading at 2 min (ft^3),
W = wet test meter volume (ft^3).

If the average percent variation from all three tests is >±3%, deliver flow meter to I&C laboratory for adjustment and recalibration.

20.17.6.7 Log Book Entries

Verify that all log book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.

20.17.6.8 System Adjustments

None.

20.17.6.9 Special Notes and Instructions

None.

20.18 CALIBRATION OF MASS SCALES

20.18.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration and field check of mass scales.

20.18.2 Applicability

This procedure applies to all standard mass scales used in the RASA program.

20.18.3 References

1. Sect. 16.3, Equipment Calibration Records

20.18.4 Definitions and Abbreviations

20.18.4.1 Definitions

LOG BOOK. Instrument Calibration Log Book located at ORNL-RASA laboratory.

CALIBRATED INSTRUMENT FILE. Calibration records external to log books maintained at the ORNL-RASA laboratory by the records technologist.

Also see Sect. 1.5 of this manual, Terminology.

20.18.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

20.18.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure, and the records technologist is responsible for the maintenance of all calibration records and files generated by this procedure.

20.18.6 Equipment and Supplies

Mass scales and check weight set (1 to 500 g).

20.18.6.1 Radiation Sources

None.

20.18.6.2 Calibration Frequency

Laboratory calibration is performed every six months and immediately following any adjustments or maintenance to scales. Field calibration is performed monthly and whenever scale operation is suspect.

20.18.6.3 Applicable Standards

None.

20.18.6.4 Calibration Procedure

Laboratory Calibration

1. Supervisor of ORNL Fabrication Department of the Plant and Equipment Division (P&E) will notify the RASA program manager or the designated instrument technologist that scale calibration is needed based on calibration frequency requirements (Sect. 6.3).
2. Transport mass scales to P&E Division for calibration.
3. Following calibration by Plant and Equipment Divisiion, enter the following information in the Instrument Calibration Log Book: date, scale number, name of calibrator, and date of next required calibration.
4. Report data in step 3 to records technologist for inclusion in the Calibrated Instrument File.
5. Verify that a calibration sticker has been placed on scale by ORNL Fabrication Department personnel.

Field check

1. Determine mass (weight) of each check weight between 1 and 500 g.
2. If the values determined in step 1 differ from the value stamped on the check weights by <±5% the scale is ready for use. If the values determined in step 1 differ from the value stamped on the check weights by >5%, recalibrate scale according to Sect. 6.5.1 of this procedure.

20.18.6.5 Calculations

None.

20.18.6.6 Log Book Entries

1. Verify that all log book entries have been made in accordance with this procedure and Equipment Calibration Records, Sect. 16.3.
2. Verify that calibration sticker has been affixed to the scale.
3. Verify that the records technologist has been notified and given calibration data following laboratory calibration.

20.18.6.7 System Adjustments

None.

20.18.6.8 Special Notes and Instructions

None.

20.19 CALIBRATION OF ELECTRONIC TEST EQUIPMENT

20.19.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration of electronic test equipment.

20.19.2 Applicability

This procedure applies to all electronic test equipment used in the ORNL-RASA program including oscilloscopes, voltmeters, signal generators, counters, etc.

20.19.3 References

None.

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

20.19.4 Definitions and Abbreviations

20.19.4.1 Definitions

See Sect. 1.5 of this manual, Terminology.

20.19.4.2 Abbreviations

EOSD Environmental and Occupational Safety Division

Also see Sect. 1.5 of this manual, Terminology.

20.19.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure.

20.19.6 Procedure

20.19.6.1 Equipment and Supplies

Test equipment to be calibrated, including voltmeters, oscilloscopes, signal generators, counters, etc.

20.19.6.2 Radiation Sources

None.

20.19.6.3 Calibration Frequency

Laboratory calibration is performed at least annually, and immediately following maintenance and repair, or when defective operation is suspected. No field calibration is performed.

20.19.6.4 Applicable Standards

None.

20.19.6.5 Calibration Procedure

1. The equipment to be calibrated is delivered to ORNL EOSD Standards Laboratory by the instrument technologist.
2. Following calibration, upon receipt of the equipment, verify the instrument identification number and calibration sticker affixed to the instrument by EOSD.

20.19.6.6 Calculations

None.

20.19.6.7 Log Book Entries

All calibration data is maintained by ORNL EOSD at their facility.

20.19.6.8 System Adjustments

None.

20.19.6.9 Special Notes and Instructions

None.

20.20 CALIBRATION OF WET TEST METERS

20.20.1 Purpose

The purpose of this procedure is to provide a method for the laboratory calibration of the wet test meters.

20.20.2 Applicability

This procedure applies to all standard wet test meters used in the ORNL-RASA program.

20.20.3 References

None.

20.20.4 Definitions and Abbreviations

20.20.4.1 Definitions

See Sect. 1.5 of this manual, Terminology.

20.20.4.2 Abbreviations

Y-12 The Department of Energy's Y-12 Plant at Oak Ridge, Tennessee

Also see Sect. 1.5 of this manual, Terminology.

20.20.5 Responsibilities

The instrument technologist is responsible for the implementation of this procedure.

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

20.20.6 Procedure

20.20.6.1 Equipment and Supplies

American Meter Company AL-19 Wet Test Meter.

20.20.6.2 Radiation Sources

None.

20.20.6.3 Calibration Frequency

Laboratory calibration is performed at least annually and immediately following maintenance and repair and when defective operation is suspected. No field calibration is performed.

20.20.6.4 Applicable Standards

None.

20.20.6.5 Calibration Procedure

1. The equipment to be calibrated is delivered to the Y-12 Calibration Laboratory by the instrument technologist.
2. Following calibration and on receipt of the equipment, verify the instrument identification number and calibration sticker affixed to the instrument by Y-12.

20.20.6.6 Calculations

None.

20.20.6.7 Log Book Entries

All calibration data are maintained by Y-12 Calibration Laboratory at their facility.

20.20.6.8 System Adjustments

None.

20.20.6.9 Special Notes and Instructions

None.

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.1. Component list for onsite gamma spectrometry systems.

Eve

1 Tracor Northern TN 1314 Display Unit
1 Tracor Northern TN 1706 Pulse Height Analyzer
1 ORTEC 490B Linear Amplifier
1 ORTEC 456 High Voltage Power Supply
1 Tennelec Tennebin 3 Nimbin Power Supply
1 Na(I) Photomultiplier/Detector System

Adam

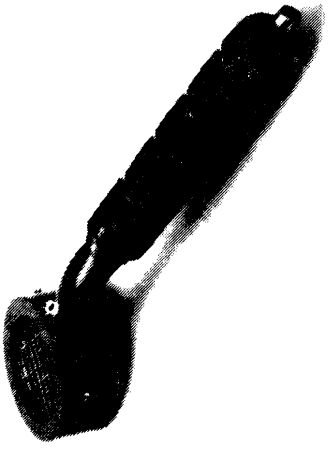
1 Nuclear Data ND 100 Pulse Height Analyzer
1 Nuclear Data ND 100 Pulse Height Digital Tape Recorder
1 ORTEC 490B Linear Amplifier
1 ORTEC 456 High Voltage Power Supply
1 Tennelec Tennebin 3 Nimbin Power Supply
1 Na(I) Photomultiplier/Detector System

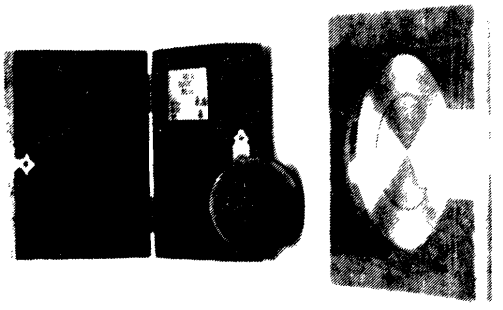
Additional Equipment (Adam and Eve)[a]

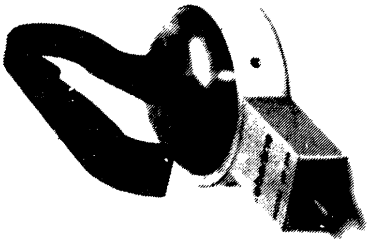
1 ORTEC 490B Linear Amplifier
1 ORNL Low Voltage 85 VDC Power Supply
2 Diode Detectors

[a]These additional components may be used to configure the system for radon daughter counting.

Exhibit 20.2. Beta-gamma pancake counters and calibration jig.







SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.3. Energy calibration procedure.

Technologist action	Terminal response	Function or comment
1. Place control console in "on line" status		
2. Enter ↑ C ↑ C	COMMAND:	Places control console in command of system
3. Enter G and press return		
4. Enter SP and press space bar	STORE, RECALL, PRINT OR MOVE?	
5. Enter RE and press space bar	SPECTRUM NUMBER? SC:	
6. Enter spectrum number desired from Laboratory Gamma Spectrometry Log Book (5/11 System) and press space bar	COMMAND	
7. Enter CA and press space bar	CALIB #? CB:	
8. Enter source number (1 for GeLi-1 calibration table and 2 for Ge-2 calibration table) and press space bar	RECALL CALIB TABLE:?	
9. Enter YES and press space bar	ANALYZE SPECTRUM FOR CALIBRATION?:	
10. Enter YES and press space bar	WIDTH PARAMETER? (4-8):	
11. Enter 4 and press space bar	REJECT LEVEL-ERROR %? (10-100):	
12. Enter 10 and press space bar	ENERGY CALIB.?:	

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.3. (Continued).

Technologist action	Terminal response	Function or comment
13. Enter YES and press space bar	DECAY TIME?:	
14. Enter 0 and press space bar	Computer output followed by DELETE PRESENT CALIBRATION	See Exhibit 20.13-2 energy calibration computer output. Circle peak number closely corre-sponding to the following energies: 63.29, 92.59, 295.20, 351.90, 609.30, 1120.20. 1764.44, 2204.1, 2614.6, keV
15. Enter NO and press space bar	ENERGY CALIBRATION?	
16. Enter YES and press space bar	DELETE ENERGY CALIBRATION VALUES?	
17. Enter YES and press space bar	DELETE ALL?	
Enter YES and press space bar	ENTER PEAK NUMBERS, ENERGIES END WITH RETURN KEY; NO. ENERGY	
18. Enter peak number and energy value and press space bar	NO.	e.g. 1 63.29 5 92.59
19. Repeat line 17 for energy values 92.59, 295.20, 351.90, 609.30, 1120.20, 1764.44, and 2204.1 keV and press space bar after each line entry	NO.	

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.3. (Continued).

Technologist action	Terminal response	Function or comment
20. Enter peak number, 2614.6 and press return	EFFICIENCY CALIBRATION?	
21. Disable Protect on D0 (left side disk drive) using Write/Protect switch. Flip switch to left for write function		Allows writing to this disk
22. Enter NO and press space bar	COMPLETE STORE CALIB. TABLE?	
23. Enter YES and press space bar	NEW CALIB NUMBER?	
24. Enter 1 for GeLi-1 or 2 for Ge-2 and press space bar	DELETE ANY PREVIOUS FILE WITH THIS NUMBER?	
25. Enter YES and press space bar	COMMAND	New calibration table will be written on disk 0
26. Enable Write Protect for D0 (left side disk drive) using Enable/Disable switch		Prevents writing to the disk
27. Enter AN and press space bar	WIDTH PARAMETER (4-8):	
28. Enter 4 and press space bar	ENERGY WINDOW FPR SEARCH? (1-3):	
29. Enter 1 and press space bar	REJECT LEVEL ERROR % (10-100)	
30. Enter 10 and press space bar	DECAY TIME	

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.3. (Continued).

Technologist action	Terminal response	Function or comment
31. Enter 0 and press space bar	Computer output	See Exhibit 20.5 energy calibration computer output
32. Compare manually entered energy values (lines 17-19) with those produced by the spectral analysis output (line 30) for each peak number. If energy values differ by ≤0.8 keV, then proceed. If any pair of values differs by >0.8 keV, then proceed with NB05 efficiency calibration, Sect. 6.1.2 of this procedure	COMMAND	
33. Enter CA and press space bar	RECALL OR CALIB.?	
34. Enter RE and press space bar	CALIB #? CB:	
35. Enter 1 for GeLi-1 or 2 for Ge-2 and press space bar	PRINT CALIB TABLE?	
36. Enter YES and press space bar	Computer output	Calibration table see Exhibit 20.7
37. Post calibration table on bulletin board near 5/11 System		
38. Submit copy of calibration table to records technologist for inclusion in Calibrated Instrument File		

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.4. Efficiency calibration procedures.

Technologist action	Terminal response	Function or comment
1. Enter ↑ C ↑ C	COMMAND	Places control console in command of system
2. Enter G and press return		
3.	?XX at XX.XX	X may be any values 0-9
4. Press expand trace switch for X10 horizontal scale expansion	*	
5. Enter X space FCUR (2, base value + 73.0) and press return	*	e.g. X FCUR (2,2688 + 73.0. GeLi detector in region 1: 73.0 = 63.29+10 channels cursor 10 channels above (to the right of) peak
6. Enter X space FCUR (1, base value + 53.0)	*	e.g. X FCUR (2,2688 + 53.0. GeLi detector in region 1. 53.0 = 63.29-10 channels cursor 10 channels below (to the left of) peak
7. Enter X space FCUR (1 base value + 63.29)	*	Place cursor on peak if spectrometer is in calibration
8. Verify coincidence between curser and peak		

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.4. (Continued).

Technologist action	Terminal response	Function or comment
9. Repeat steps 4-6 for each remaining energy value: 95.29, 295.20, 351.90, 609.30, 1120.20 1764.55, 2201.1 and 2614.6 keV		If all cursor values (line 6) coincide with peak energy values, proceed; if cursors are out of coincidence, see Sect. 20.12.6 System Adjustments
10. Switch off Expand Trace switch		
11. Enter ↑ C ↑ C	COMMAND:	
12. Enter G and press return		
13. Enter SP and press space bar	STORE, RECALL, PRINT OR MOVE	
14. Enter MO and press space bar	REGION (0, 1, 2)	
15. Enter 1 for GeLi-1 2 for Ge-2	SAMPLE ID	0 reserved for computer analysis region
16. Enter NB05 and press space bar	SAMPLE WT OR VOLUME	
17. Enter 441.5 and press space bar	COMMAND, RECALL OR CALIB	
18. Enter CA and press space bar	CALIB #? CB	
19. Enter 1 for GeLi-1 or 2 for Ge-2 detector and press space bar	RECALL CALIB TABLE	
20. Enter NO and press space bar	ANALYZE SPECTRUM FOR CALIBRATION	

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.4. (Continued).

Technologist action	Terminal response	Function or comment
21. Enter YES and press space bar	WIDTH PARAMETER (4-8)	
22. Enter 4 and press space bar	REJECT LEVEL ERROR % (10-100):	
23. Enter 10 and press space bar	ENERGY CALIB?	
24. Enter YES and press space bar	DECAY TIME?:	
25. Enter 0 and press space bar	Computer Output	Energy calibration computer output see Exhibit 20.5
26. Choose peak numbers closely corresponding to the following energies: 63.29, 95.29, 295.20, 351.90, 609.30, 1120.20, 1764.44, 2209.1, and 2614.6 keV	DELETE PRESENT CALIBRATION	
27. Enter YES and press space bar	ENERGY CALIBRATION	
28. Enter YES and press space bar	ENTER PEAK NUMBER, ENERGIES END WITH RETURN KEY; NO. ENERGY	
29. Enter peak number, energy value, and press space bar	NO. ENERGY	e.g. 1 63.29
30. Repeat line 27 for energy values 95.29, 259.20, 351.90, 609.30, 1120.20, 1764.44, and 2204.1 keV	NO. ENERGY	

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.4. (Continued).

Technologist action	Terminal response	Function or comment
31. Enter peak number, 2614.6, and press return	EFFICIENCY CALIBRATION	
32. Enter YES and press space bar	NO. ENERGY HALF-LIFE ACTIVITY E.T.	
33. Enter peak number, Energy, half-life in days, known activities in gammas/sec, and elapsed time in days since source calibration and press space bar		
34. Enter peak number, 2204.1 5.38E+05 139.11 XX.XX and press space bar		
35. Enter peak number, 1764.4 5.83D+05 441.35 XX.XX and press space bar		
36. Enter peak number, 1120.2 5.83E+05 421.8 XX.XX and press space bar		
37. Enter peak number, 609.4 5.83E+05 1293.2 XX.XX and press space bar		
38. Enter peak number, 351.9 5.83E+05 1293.2 XX.XX and press space bar		

Exhibit 20.4. (Continued).

Technologist action	Terminal response	Function or comment
39. Enter peak number, 295.20 5.83E+05 536.33 XX.XX and press space bar		
40. Enter peak number, 92.59 2.41E+01 151.12 XX.XX and press space bar		
41. Enter peak number, 63.29 2.41E+01 146.15 XX.XX and press return	COMPLETE STORE CALIB TABLE	
42. Disable Protect on D0 (left side disk) drive using Write/Protect switch. Flip switch to left		Allows data to be written out to disk
43. Enter YES and press space bar	NEW CALIB NUMBER?	
Enter 1 for GeLi-1 or 2 for Ge-2 detectors and press space bar	DELETE ANY PREVIOUS FILE WITH THIS NUMBER?	
44. Enter YES and press space bar	COMMAND	Writes new efficiency calibration on disk
45. Enable Write Protect for D0 (left side disk drive) using Write/Protect switch. Flip switch back to right		Prevents writing to disk
46. Enter AN and press space bar	WIDTH PARAMETER (4-8):	

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.4. (Continued).

Technologist action	Terminal response	Function or comment
47. Enter 4 and press space bar	ENERGY WINDOW FOR SEARCH? (1-13):	
48. Enter 1 and press space bar	REJECT LEVEL-ERROR% (10-100):	
49. Enter 10 and press space bar	DECAY TIME	
50. Enter 0 and press space bar	Computer output	Energy calibration computer output see Exhibit 20.5
51. Enter CA and press space bar	RECALL; OR CALIB?:	
52. Enter RE and press return	CALIB. #? CB:	
53. Enter 1 for GeLi-1 or 2 for Ge-2 and press space bar	PRINT CALIB. TABLE?	
Enter YES and press space bar	Computer output	Energy calibration computer output see Exhibit 20.5
54. Post output calibration table on 5/11 system bulletin board and submit a copy to the records technologist for inclusion in the Calibrated Instrument File		

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.5. System output.

COUNTING TIME = 3600 SECONDS (LIVE)

NO.	NUCLIDE	PK.LOC.	FWHM	BKGND.	AREA	ERROR %	ENERGY
NP=	FIT= 7.37	8.35	10.26	10.55			
1	------	63.3	1.51	4.33E+04	7.33E+03	8.8	63.3
NP= 3	FIT= 437.44	299.69	479.65	265.69			
NP= 4	FIT= 224.39	226.35					
NP= 4	FIT= 77.80	67.32	67.42				
NP= 5	FIT= 14.68	12.96	13.27				
2*	------	84.0	1.52	7.55E+04	4.79E+03	14.2	84.0
3*	------	87.3	1.52	7.55E+04	1.14E+04	5.8	87.3
4*	------	90.0	1.52	7.55E+04	4.90E+03	11.5	90.0
5*	------	92.7	1.52	7.55E+04	1.82E+04	4.3	92.7
6*	------	94.8	1.52	7.55E+04	2.30E+03	26.2	94.8
NP= 1	FIT= 9.57	9.24					
NP= 2	FIT= 9.31	5.31	5.18				
7*	------	108.9	1.55	4.69E+04	3.48E+02	58.9	108.9
8*	------	112.5	1.55	4.69E+04	8.78E+02	47.0	112.5
NP= 1	FIT= 1.57	1.60					
9	------	144.1	1.53	5.41E+04	3.22E+03	6.4	144.1
NP= 1	FIT= 4.01	3.97					
10	------	186.1	1.59	5.67E+04	2.59E+04	1.9	186.1
NP= 1	FIT= 1.67	1.67					
11	------	236.0	1.45	2.09E+04	1.79E+03	8.3	236.0
NP= 1	FIT= 0.33	0.48					
12	------	242.1	1.51	2.14E+04	2.46E+04	0.7	242.1
NP= 2	FIT= 6.59	2.85	2.00	1.99			
13*	------	256.4	1.55	2.40E+04	1.04E+03	13.3	256.4
14*	------	259.0	1.55	2.40E+04	1.78E+03	8.6	259.0
NP= 2	FIT= 23.95	19.12	16.81	15.98			
NP= 3	FIT= 3.12	1.87	1.11	1.07			
15*	------	269.6	1.67	2.36E+04	1.98E+03	7.1	269.6
16*	------	271.4	1.67	2.36E+04	1.57E+03	9.2	271.4
17*	------	274.8	1.67	2.36E+04	1.14E+03	10.4	274.8
NP= 1	FIT= 3.90	4.80	4.09	4.09			
NP= 2	FIT= 0.39	0.42					
18*	------	292.8	1.56	1.67E+04	3.21E+02	26.4	292.8
19*	------	295.3	1.56	1.67E+04	5.29E+04	0.4	295.3
NP= 1	FIT= 1336.73	4.34	194.06	34.30			
NP= 2	FIT= 1.42	1.43					
20*	------	349.8	1.60	1.25E+04	1.04E+03	13.8	349.8
21*	------	351.9	1.60	1.25E+04	8.83E+04	0.5	351.9
NP= 1	FIT= 2.11	2.08					
22	------	388.3	1.98	1.16E+04	6.61E+02	20.7	388.3
NP= 1	FIT= 10.48	8.56	8.53				
NP= 2	FIT= 3.04	2.62					
23*	------	607.1	1.76	5.41E+03	5.62E+02	31.3	607.1
24*	------	609.0	1.76	5.41E+03	6.20E+04	0.8	609.0
NP= 1	FIT= 0.45	0.48					
25	------	665.[illegible]		[illegible]E+03	1.76E+03	[illegible]	
NP= 1	FIT= 5.97						
2	FIT=						

Exhibit 20.6. Sample holder calibration values.

CAROUSEL

Energy No.	#1	#2
1	62.0	92.6
2	92.6	295.2
3	295.2	351.9
4	351.9	609.3
5	609.3	1120.2
6	1120.2	1764.4
7	1764.4	2204.1
8	2204.1	2614.6
9	2614.6	

PETRI

1	62.0	62.0
2	92.6	92.6
3	295.2	295.2
4	351.9	351.9
5	609.3	609.3
6	1120.2	1120.2
7	1764.4	1764.4
8	2204.1	2204.1

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.6 (Continued).

GLASS DEWAR

Energy No.	#1	#2
1	77.1	80.4
2	87.3	89.5
3	295.2	295.2
4	351.9	351.9
5	609.3	609.3
6	1120.2	1120.2
7	1764.4	1764.4
8	2204.1	2204.1

CRYOFAB DEWAR

1	77.1	77.1
2	241.9	295.2
3	295.2	352.0
4	352.0	609.4
5	1120.3	1120.3
6	1764.6	1764.6
7	2204.1	2204.1

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.7. Calibration table.

COMMAND: CA

RECALL, OR CALIB? :RE

CALIB. # ? CB:1

PRINT CALIB. TABLE? YES

CALIB. # 1

ENERGY CALIB. VALUES:

NO.	CHANNEL	ENERGY
1	63.1	62.0
2	92.7	92.6
3	25.6	295.2
4	352.4	351.9
5	609.9	609.3
6	1120.9	1120.2
7	1765.0	1764.4
8	2204.2	2204.1

SUBJECT: MEASURING AND TEST EQUIPMENT CALIBRATION

Exhibit 20.7. (Continued).

EFFIC. CALIB. VALUES:

NO.	ENERGY	EFFIC.
1	62.0	4.82E+01
2	92.6	2.36E+01
1	295.2	3.88E+01
2	351.9	4.70E+01
3	609.3	9.65E+01
4	1120.2	1.79E+02
5	1764.4	2.51E+02
6	2204.1	3.34E+02

Exhibit 20.8. Wrenn chamber calibration apparatus.

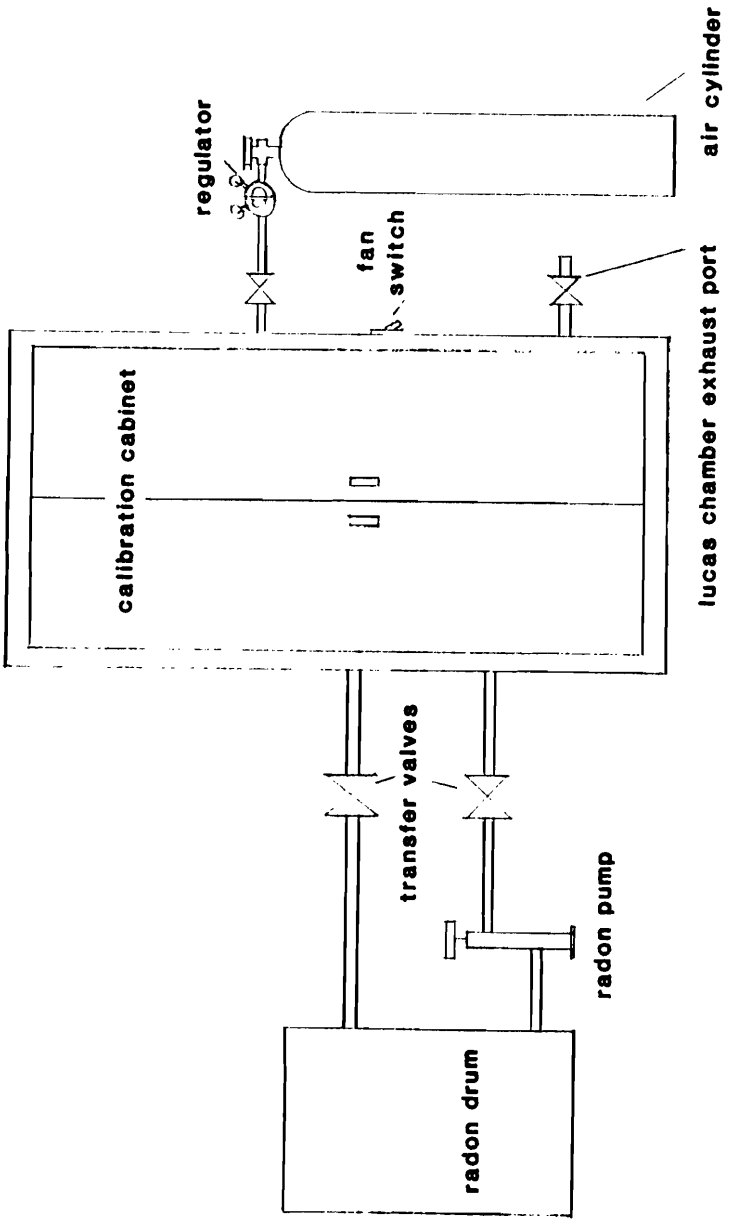


Exhibit 20.9. Emanation tube.

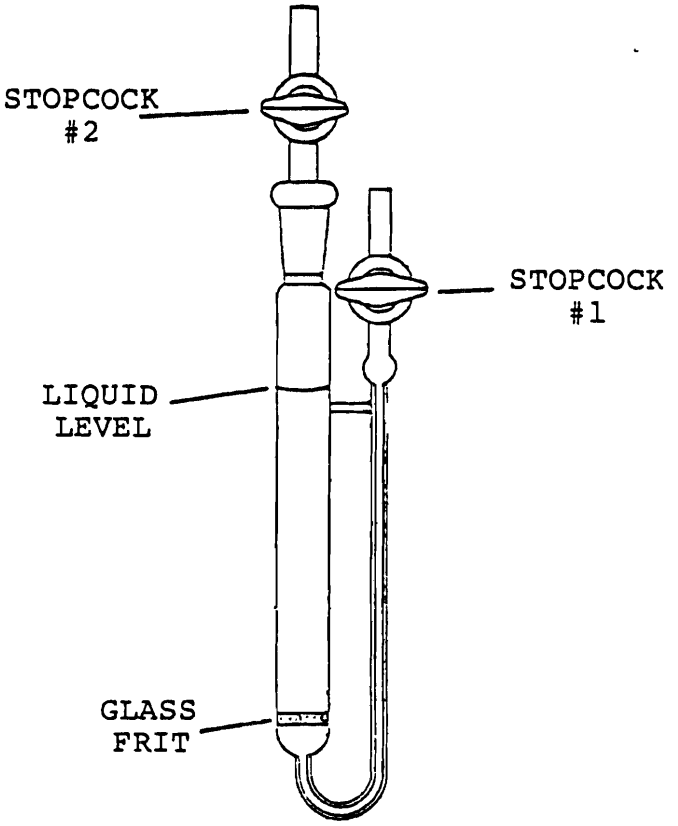


Exhibit 20.10. Low volume air pump apparatus schematic.

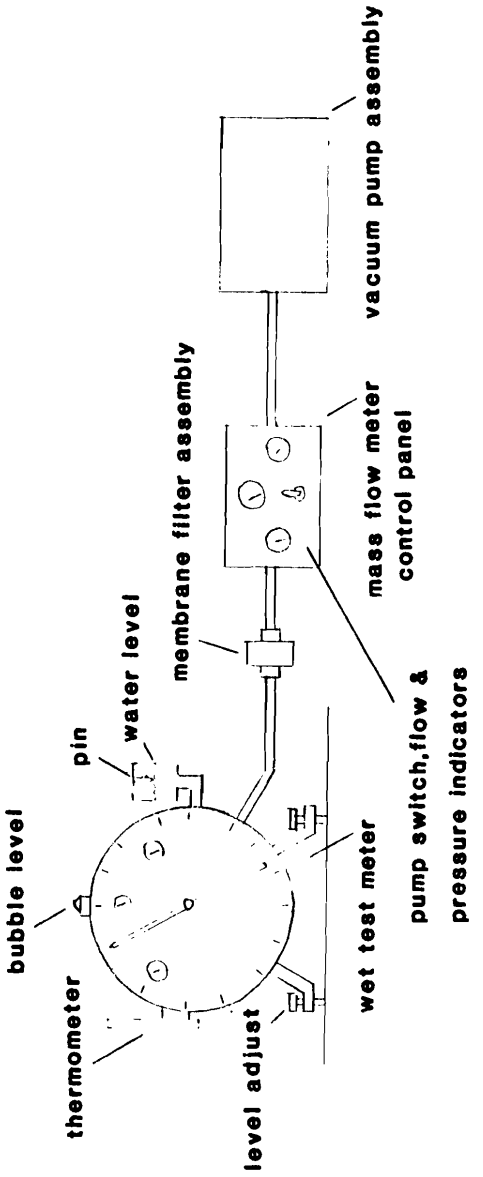


Exhibit 20.11. Mass scale photograph.

21. COMPUTER OPERATION

21. COMPUTER OPERATION

21.1 APPLICATIONS SOFTWARE DOCUMENTATION

21.1.1 Purpose

The purpose of this procedure is to provide recommended guidance in the preparation of computer program documentation.

21.1.2 Applicability

This procedure applies to all computer programs generated by ORNL-RASA for internal use on systems controlled exclusively by ORNL-RASA.

21.1.3 References

1. Sect. 21.2, Software Verification and Validation
2. ANSI N413-1974, Guidelines for the Documentation of Digital Computer Programs (for guidance only)

21.1.4 Definitions and Abbreviations

21.1.4.1 Definitions

DOCUMENTATION. All supporting data used to produce a computer program and explain the operation of the program.

REMARKS. Explanatory statements within the body of the program serving no function with respect to the operation of the program.

PROGRAMMER. Instrument or laboratory technologist generating the computer program.

PROGRAM FILE FOLDER. Repository for all program documentation.

Also see Sect. 1.5 of this manual, Terminology.

21.1.4.2 Abbreviations

See Sect. 1.5 of this manual, Terminology.

SUBJECT: COMPUTER OPERATION

21.1.5 Responsibilities

The ORNL-RASA program manager is responsible for the implementation of this procedure, and the laboratory or instrument technologist generating the program is responsible for the documentation of the program and retention of all documentation.

21.1.6 Procedure

21.1.6.1 Format

A free style format is employed by ORNL-RASA in the generation of computer documentation, enabling the programmer to use his (her) judgment and discretion.

21.1.6.2 Recommended Content

1. Identification or name to uniquely identify the program
2. Abstract defining what the program does
3. Methodology summarizing the input and output ranges and constraints, theory and mathematical derivations employed
4. Subroutines and libraries used in the program
5. Author of program
6. References used in program development
7. Error messages and their interpretation
8. Program listing (a hard copy listing of the computer code)

21.1.6.3 Program Modification

All program changes should be documented and the documentation placed in the Program File Folder.

21.2 SOFTWARE VERIFICATION AND VALIDATION

21.2.1 Purpose

The purpose of this procedure is to provide recommended guidance for the verification and validation of computer programs prior to use in the ORNL-RASA program.

21.2.2 Applicability

This procedure applies to all computer programs generated by ORNL-RASA for internal use on systems controlled exclusively by ORNL-RASA.

21.2.3 References

Sect. 21.1, Applications Software Documentation

21.2.4 Definitions and Abbreviations

21.2.4.1 Definitions

VERIFICATION AND VALIDATION. The process of assuring that a computer program functions in an error-free mode.

PROGRAMMER. Instrument or laboratory technologist generating the computer program.

DEBUGGING. Modification of a computer program to eliminate program errors and malfunctions.

BRANCHING. A decision point in the computer program in which the program follows one of two or more paths.

PROGRAM FILE FOLDER. Repository for all program documentation.

Also see Sect. 1.5 of this manual, Terminology.

21.2.5 Responsibilities

The ORNL-RASA program manager is responsible for the implementation of this procedure, and the laboratory or instrument technologist generating the program is responsible for the verification and validation of the program.

21.2.6 Procedure

1. Verification and validation will be performed following debugging and prior to implementation as an operating system in the ORNL-RASA program.
2. All mathematical functions will be verified and validated using hand calculations (calculators), established literature values, where applicable, or other operating computer systems and comparing the results with the output of the computer program.
3. A series of verification and validation calculations should be performed which tests the accuracy of the program throughout the usable range of input and output values.
4. An effort should be made by proper adjustment of input data values to force the program through all elements of branching points in the program.
5. Wherever possible, verification and validation should be performed by an individual not directly connected with the generation of the computer program.
6. All verification and validation documentation will be placed in the Program File Folder according to Sect. 21.1, Applications Software Documentation.

21.3 OPERATIONAL LOGS AND RECORDS

21.3.1 Purpose

The purpose of this procedure is to describe the computer systems operational logs and records used in the ORNL-RASA program.

21.3.2 Applicability

This procedure applies to all computer systems used and controlled exclusively by ORNL-RASA.

21.3.3 References

1. Sect. 15.1, Determination of Radionuclides in Soil and Sediment Samples

21.3.4 Definitions and Abbreviations

21.3.4.1 Definitions

OPERATIONAL LOGS AND RECORDS. Information concerning the operation of computer systems but limited to the logging of samples, types, dates, operator, etc., for the purpose of determining which samples have been analyzed and the location of data.

Also see Sect. 1.5 of this manual, Terminology.

21.3.4.2 Abbreviations

ND SYSTEM Nuclear Data Gamma Spectrometer System

5/11 SYSTEM Tennecomp 5/11 Gamma Spectrometer System

Also see Sect. 1.5 of this manual, Terminology

21.3.5 Responsibilities

The laboratory technologist assigned to soil counting is responsible for the implementation of this procedure, and the records technologist is responsible for the systematic retention of records and data received from the laboratory technologist.

21.3.6 Procedure

21.3.6.1 ND System

Operational logs and records for the ND System are maintained by the laboratory technologist in the ND System Sample Counting Log Book. Specific log book entry requirements are addressed in Determination of Radionuclides in Soil and Sediment Samples, Sect. 15.1. When the log book is filled, the laboratory technologist will forward it to the records technologist for filing.

21.3.6.2 5/11 System

Operational logs and records for the 5/11 System are maintained by the laboratory technologist in the 5/11 System Sample Counting Log Book. Specific log book entry requirements are addressed in Determination of Radionuclides in Soil and Sediment Samples, Sect. 15.1. When the log book is filled, the laboratory technologist will forward it to the records technologist for filing.

21.3.6.3 Additional Logs and Records

As needed, additional logs and records may be developed for other systems. As they are developed, revision of this procedure is required.

APPENDIX

APPENDIX

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ANSI N45.2.9-1979, Requirements for the Collection, Storage and Maintenance of Quality Assurance Records for Nuclear Power Plants (for guidance only).

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ASTM-D3370-76, Part 31, Water Method (for general guidance only).

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EPA-600/4-77-001, January 1977, *Environmental Radioactivity Laboratory Intercomparison Studies Program* (for guidance only).

D-2-1 Standard Practice Procedure Martin Marietta Energy Systems, Procurement of Material.

APPENDIX (Continued)

D-2-8 Standard Practice Procedure, Martin Marietta Energy Systems, Consultant and Special Services.

D-2-8S ORNL Supplement Standard Practice Procedure, Martin Marietta Energy Systems, Consultant and Special Services.

D-2-16 Standard Practice Procedure, Martin Marietta Energy Systems, Quality Assurance Program.

D-2-16S ORNL Supplement, Standard Practice Procedure, Martin Marietta Energy Systems, Quality Assurance Program.

D-3-1, Standard Practice Procedure, Employment.

Series D-5-1, Contamination or Damage to Personal Property, Martin Marietta Energy Systems, Standard Practice Procedures.

D-5-8, Standard Practice Procedures, Martin Marietta Energy Systems, News Release to Media.

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Health Physics Manual, Procedures and Practices for Radiation Protection, Martin Marietta Energy Systems Procedure 3.0, Personnel Exposure Control.

ORNL/CF-79/53 Guidelines for Subcontracting at ORNL.

"Performance Standards and Measures of Performance for the ORNL-RASA Program Manager."

Martin Marietta Energy Systems Procurement Division Manual.

USNRC Reg. Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment (for guidance only).

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