Approved by:		
	General Manager	Radiation Safety Officer

STANDARD OPERATING PROCEDURE

15.OPS.08

OPERATION OF ALPHA-BETA SCINTILLATION DETECTORS

1.0 OBJECTIVE

To provide instruction for the operation of dual alpha and beta radiation detectors for the measurement of surface radioactivity for incoming, free release, routine, and health and safety surveys.

2.0 SCOPE

This standard operating procedure (SOP) applies to the operation of radiation survey meters with external scintillation probes to measure alpha and/or beta radiation. These instruments may be used to determine surface alpha or beta radioactivity levels. These instruments may only be used where surface geometry and other environmental conditions permit. The instrument specifically referenced by this SOP is the Ludlum 43-93 alpha-beta scintillation detector with Ludlum 2360 alpha-beta data logger.

3.0 POLICY

Instruments will be used in accordance with manufacturer's recommendations, SOPs, and site-specific requirements by trained personnel. The use of an instrument outside of its intended capabilities requires approval by the CHDT Radiation Safety Officer (RSO) or designee.

4.0 RESPONSIBILITIES

Responsibilities of the CHDT RSO, management, and staff are defined in the CHDT Radiation Protection Plan (SOP DR 15.RPP.01).

5.0 SURVEY DATA COLLECTION

5.1 Instrument Description

The Ludlum Model 43-93 contains a plastic scintillator in a 100 square centimeter active detector window. The detector has a thin mylar covering along with a protective screen. The 43-93 is used with a 2360 alpha-beta data logger. The front panel controls on the 2360 include a rotary switch for selecting the 4 decade range and instrument shut off, an audio on/off switch, a fast/slow response switch, a toggle switch for the alpha, beta, and dual (alpha+beta) channels, and a rotary switch for scaler counting time, ranging from 0.1 to 60 minutes, with an option for a user-defined time set by the system software on a computer. The scaler count is enabled by a button on the top of the meter handle. The 2360 also has a data logging feature, which can store up to 550 measurements and which may be downloaded to a computer by the RS-232 port at the base of the unit.

5.2 Instrument Setup and Initial Quality Control

Upon receipt of the instrument through purchase or rental, the following steps should be taken to initially setup the instrument and verify that it is in good working order.

- Verify that the instrument calibration is current; confirm that serial number on instrument matches that on the calibration certificate; confirm high voltage (HV) setting on instrument with calibration
- Perform ten (10) initial background quality control (QC) measurements
  - Use a location away from radioactive sources in a consistent geometry
  - Use the 1- or 2-minute scaler count setting, based on requirements determined by the CHDT RSO.
  - Depress the scaler count button to initiate the count. Colons (":") will be present in the digital readout during the scaler count. After the count is complete, record the measurement, and repeat for 10 measurements.
  - For background, a single count will record the background alpha and beta measurements; record each individually.
  - Calculate the average plus and minus 20%. Subsequent background QC measurements must fall within this range. Typical alpha background is between 0 and 2 counts per minute (cpm); beta backgrounds may range from 100 to 300 cpm, depending on location.
- Perform ten (10) initial source QC measurements
  - Use thorium-230 source for alpha measurements and technicium-99 source for beta measurements in a repeatable geometry (i.e., orientation of the source relative to the meter).
  - Use same location as background measurements
  - Depress the scaler count button to initiate the count. Colons (":") will be present in the digital readout during the scaler count. After the count is complete, record the measurement, and repeat for 10 measurements. Record the alpha measurement when using the thorium-230 source, and the beta measurement when using the technicium-99 source.
  - Calculate the average for each radiation plus and minus 20%. Subsequent source QC measurements must fall within this range.

5.2.1 Daily Instrument Quality Control

Each day that the instrument is used, the following QC checks and measurements must be performed and recorded.

- Check the battery by depressing the "BAT" button
- Check the HV against the calibrated HV
- Perform background QC measurement

- Use same location as with initial QC measurements
- Measurement must be within plus or minus 20% of the initial average

- Perform alpha and beta source QC measurement
  - Use same location and source geometry as with initial QC measurements
  - Measurement must be within plus or minus 20% of the initial average

If either measurement does not fall within the required tolerances, turn the unit off, turn it back on, and repeat the measurement(s). If the unit fails a second consecutive time, remove the unit from service and notify the CHDT RSO or designee.

5.2.2 Collection of Survey Measurements

Measurements may be collected with the 43-93 either by scanning (using the ratemeter on the 2360) or by direct counting (using the scaler count feature of the 2360). Scanning measurements are typically not effective in detecting alpha radiation due to its short range in air; however, scanning may be performed for beta radiation. When conducting scanning measurements, the audio output of the meter should be audible to the technician so that changes in count rate may be identified without looking away from the surface being surveyed. The mylar window is very thin and fragile, and may be easily torn if it comes into contact with a rough surface. The technician should be familiar with the typical beta count rates expected in the survey environment, which will assist in identifying anomalous count rates. Scanning measurements are collected by moving the detector slowly over the surface, noting any increases in count rate.

Scaler measurements are collected by leaving the probe stationary over a given location, and initiating a scaler count with the meter (typically one minute in length). To allow for consistent measurement geometry, it may be necessary to rest the probe on the surface being measured. However, please note that this action *may result in contamination of the probe* and appropriate precautions should be taken to prevent cross contamination (e.g., the use of removable spacers on the probe, routine wipe and decontamination of probe surfaces, etc). For scaler measurements with the 43-93, record both the alpha and beta measurements.

5.2.3 Evaluation of Results

The 43-93 and 2360 report results in units of cpm. For a meaningful comparison with surface radioactivity limits, the measurement units of cpm will require conversion to decays per minute per 100 square centimeters (dpm/100 cm^2). The following equation will be used to convert the raw measurement in cpm to dpm/100 cm^2:

$$\frac{dpm}{100\,cm^2} = \frac{\frac{C_S}{T_S}}{\varepsilon_T \times (A/100)}$$

Where:

C_S = integrated counts by the instrument

T_S = time period over which the counts were recorded, in minutes

ε_T = total efficiency of the instruments in counts per disintegration; effectively the product of the instrument efficiency (ε_i) and the source efficiency (ε_s)

A = the physical (or "active") probe area in cm^2

Instrument efficiencies may be determined from QC data, from annual instrument calibration certificates, or from the manufacturer's published values. The CHDT RSO or designee will determine the appropriate efficiency to use for a given application. In the absence of application-specific values, standard instrument efficiencies of 0.15 cpm/dpm for alpha radiation and 0.20 cpm/dpm for beta radiation will be used. The measurement may be corrected for background by subtracting an appropriate background value (e.g., representative of the surface or environment) from the raw measurement.

6.0 STANDARDS AND CRITERIA

Specific surface radioactivity limits may be established for the type of survey being performed. The CHDT RSO or designee should be consulted to determine the appropriate limits for any new activity. Release criteria are listed in SOP DR.OPS.13, *Equipment Surveys*, and in other SOPs.

The minimum detectable concentration (MDC) (or minimum detectable activity [MDA]) of the instrument should be known prior to its use to verify that the measurement sensitivity is sufficient for the application. The MDC for a static measurement when background and sample count times are the same may be calculated using the following equation from Abelquist 2001:

$$Static\ MDC\left(\frac{dpm}{100\ cm^2}\right)=\frac{3+4.65\sqrt{C_B}}{\varepsilon_S\varepsilon_i\left(\frac{A}{100}\right)T}$$

Where:

C_B = background counts in time T

T = time period over which counts were recorded, in minutes (for one-minute counts, this value is 1)

ε_s = surface efficiency; values default to 0.25 for alpha and 0.50 for beta if no other information is available

ε_i = instrument efficiency; values default to 0.15 for alpha and 0.20 for beta if no other information is available

A = the physical (or "active") probe area in cm^2

The static measurement MDC when background and sample counting times are different may be calculated using the following equation:

$$Static\ MDC\left(\frac{dpm}{100\ cm^2}\right)=\frac{3+3.29\sqrt{R_B T_{S+B}\left(1+\frac{T_{S+B}}{T_B}\right)}}{\varepsilon_S\varepsilon_i\left(\frac{A}{100}\right)T_{S+B}}$$

Where:

R_B	=	background count rate, cpm
T_B	=	background count time, minutes
T_{S+B}	=	sample count time, minutes
ε_s	=	surface efficiency; values default to 0.25 for alpha and 0.50 for beta if no other information is available
ε_i	=	instrument efficiency; values default to 0.15 for alpha and 0.20 for beta if no other information is available
A	=	the physical (or "active") probe area in cm^2

Measurements for release of equipment or materials should be conducted so that the MDCs reflect sufficient sensitivity for the release criteria. Only results from static measurements may be compared with release criteria; due to higher MDCs, scanning measurements should not be used to determine compliance with release criteria unless project- or task-specific scanning MDCs have been developed by the CHDT RSO.

7.0 REFERENCES

49 CFR 173. *Shippers – General Requirements for Shipments and Packagings*. Current Version.

Abelquist 2001. *Decommissioning Health Physics: A Handbook for MARSSIM Users*, Institute of Physics Publishing, Philadelphia, Pennsylvania.

ANSI/HPS 1999. Surface and Volume Radioactivity Standards for Clearance.

Ludlum Measurements, Inc., Instruction Manual Model 43-93 Alpha Beta Scintillation Detector, Current Version.

Ludlum Measurements, Inc., Instruction Manual Model 2360 Alpha Beta Data Logger, Current Version.