Approved by:	General Manager	Radiation Safety Officer

STANDARD OPERATING PROCEDURE

15.OPS.04

OPERATION OF ALPHA-BETA COUNTER

1.0 OBJECTIVE

To define general and specific methods and procedures for conducting sample analysis for detection of alpha and beta radiation using the Ludlum 3030 alpha-beta tray counter in support of radioactive material disposal at the Clean Harbors CHDT (CHDT) landfill.

2.0 SCOPE

Radiation surveys, including the analysis of removable surface contamination, for regulated waste shall be performed to ensure that waste received at the CHDT landfill is consistent with the regulated waste acceptance criteria as defined in the CHDT Radiation Protection Plan.

3.0 POLICY

Radiation surveys shall be conducted by trained CHDT staff to verify that radioactive materials from other sources are not disposed at the CHDT landfill.

4.0 RESPONSIBILITIES

Responsibilities of the CHDT Radiation Safety Officer (RSO), management, and staff are defined in the CHDT Radiation Protection Plan.

5.0 GENERAL METHODS FOR ALPHA-BETA SAMPLE ANALYSIS

5.1 General Discussion

Surface contamination samples shall be collected on two inch diameter filter media and transported to the CHDT laboratory for counting with the Ludlum Model 3030 Alpha Beta Scaler using the following procedure:

- Verify that the Ludlum Model 3030 has power and is ready to count samples
- Perform the quality control (QC) daily check as described in the instrument manual. With the system in automatic mode, a QC check will be automatically required every 24 hours, and the instrument will be inoperable in the absence of a satisfactory QC check.
    - Change the count time dial to 5 minutes, and depress the "QC" button on the unit to start the instrument's automatic daily QC routine. The first required measurement is alpha, which will require the thorium-230 (^{230}Th) source.
    - After satisfactory completion of the 230Th measurement, the display will indicate that a beta source measurement is required. A technicium-99 (^{99}Tc) source should be used for another 5-minute count.

- After satisfactory completion of the ^{99}Tc measurement, a 20-minute background measurement is required.

- Set the "background subtract" mode to subtract background for alpha and beta radiation.
- For measurements of smears, the count time dial should be set to 1-minute, or as directed by the CHDT RSO. The measurement will be logged, and should be recorded on the appropriate form.
- If smear results are elevated, bias from radon progeny may be a factor. Allow 5 to 10 minutes of decay time for the smear and conduct a recount. If the count results remain in excess of the survey limit, notify the individual performing the survey and the CHDT RSO.
- Determine if the sample is less than the survey limits defined for the specific survey being conducted. Radioactivity limits are described in the appropriate SOPs. Note that the sum of fractions rule is used to determine overall compliance for alpha and beta emitting radionuclides.
- Using the PC based software, details for each sample count for later reference and analysis may be recorded if necessary.

5.2 Data Download

On a weekly basis, the data logged on each counter must be downloaded. The memory has a limit of 600 measurements, and measurements collected after the memory is full will not be logged. The laboratory desktop computer will be the primary location for downloading data. To download data, attach the serial cable to the back of the 3030 unit, attach it to a USB port on the computer using the serial-to-USB converter, and double-click on the Ludlum 3030 software. Click on the Data Logging tab, and the "Get Samples" button – the data will download from the unit, with a progress bar at the bottom of the window. A numerical count will also appear on the 3030 display. Following complete download, click the "Save Samples" button and save the file in the folder for that instrument with the filename in the following format: "XXXXXX MMDDYY Download" – where XXXXXX is the six-digit serial number and MMDDYY is the date (without spaces, dashes, or slashes). The file will save as a text/Excel spreadsheet.

Double-click on the data file to confirm that it has been completely saved. Once confirmed that the data are complete, click on the "Clear Samples" button in the 3030 software to clear the 3030 memory.

6.0 STANDARDS AND CRITERIA

6.1 Measurement Evaluation

Removable activity measured by smear samples will be evaluated against the values listed in Table 1, from ANSI/HPS N13.12-1999 (ANSI/HPS 1999). In the absence of radionuclide data to establish the appropriate screening group, the most conservative screening levels will be used.

Table 1 – Surface Contamination Limits for Free Release Surveys

Radionuclide Group	Surface Screening Levels (Bq/cm^2)	Surface Screening Levels ($dpm/100cm^2$)[(a)]	Removable Contamination Limits ($dpm/100cm^2$)
Group 1 Radium and Thorium: ^{210}Po, ^{210}Pb, ^{226}Ra, ^{228}Ra, ^{228}Th, ^{230}Th, ^{232}Th, and associated decay chains[(b)]	0.1	600	60 alpha
Group 2 Uranium: ^{234}U, ^{235}U, ^{238}U, natural uranium[(c)], and associated decay chains	1	6,000	600 alpha
Group 3 General Beta-Gamma Emitters: ^{24}Na, ^{36}Cl, ^{59}Fe, ^{109}Cd, ^{131}I, ^{129}I, ^{144}Ce, ^{198}Au, ^{241}Pu, and others	10	60,000	600 beta
Group 4 Other Beta-Gamma Emitters: ^{3}H, ^{14}C, ^{32}P, ^{35}S, ^{45}Ca, ^{51}Cr, ^{55}Fe, ^{63}Ni, ^{89}Sr, ^{99}Tc, ^{111}In, ^{125}I, ^{147}Pm, and others	100	600,000	600 beta

(a) Rounded to one significant figure.
(b) For decay chains, the screening levels represent the total activity (i.e. the activity of the parent plus the activity of all progeny) present.
(c) Where the Natural Uranium activity equals 48.9% from ^{238}U, plus 48.9% from ^{234}U, plus 2.25% from ^{235}U.

6.2 Transportation – Non-Fixed Contamination

Contamination control limits for non-fixed (i.e., removable) surface contamination are established by the Department of Transportation (DOT) in 49 CFR 173.443. Additional requirements for empty packaging are established in 49 CFR 173.428. These limits are summarized in Table 2.

Table 2 – DOT Non-Fixed Surface Contamination Limits

Radionuclide Group	Maximum Permissible Limit (Bq/cm^2)	Maximum Permissible Limit (dpm/cm^2)[(a)]	Maximum Permissible Limit ($dpm/100\ cm^2$)[(a)]	Maximum Permissible Limit for Empty Packaging ($dpm/100\ cm^2$)[(a)]
1. Beta and gamma emitters and low-toxicity alpha emitters	4	220	2,200	220,000
2. All other alpha-emitting radionuclides	0.4	22	220	22,000

(a) Averaged over 300 cm^2.

6.3 Quality Control

Quality control (QC) measurements will be collected on a daily basis. The 3030 has a built-in feature that requires a QC measurement every 24-hour period. Checks will be performed with plated alpha (^{230}Th) and beta (^{99}Tc) sources that are National Institute of Standards and Technology (NIST)-traceable. The QC tolerances will be set at +/- 15%. If the daily QC check fails, the instrument will not be used and will be taken out of service until the RSO is able to determine a cause.

6.4 Minimum Detectable Concentration

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 Ludlum 3030 uses a software routine to calculate the MDC, or it may be calculated manually. 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 1.0 for alpha and beta if no other information is available

ε_i = instrument efficiency; values default to 0.39 for alpha and 0.29 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 1.0 for alpha and beta if no other information is available

ε_i = instrument efficiency; values default to 0.39 for alpha and 0.29 for beta if no other information is available

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

The equation used by the Ludlum 3030 to calculate the MDC automatically is as follows:

$$MDC(dpm)=\frac{2.71+CL*\sqrt{R_B \times T_{S+B} \times \left(1+\frac{T_{S+B}}{T_B}\right)}}{E \times T_{S+B}}$$

Where:

CL = Confidence Level; for 95% CL = 3.290

E = Overall instrument efficiency

As there is little difference between the results of the two calculations, either equation can be used when manually calculating the MDC.

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 3030 Alpha Beta Sample Counter Meter, Current Version.