WAC 173-408-990 Appendix II. OTM-51 – UAS Application of Method 21 for Surface Emission Monitoring of Landfills.

1.0 Background on OTM-51

This method provides procedures for use of unmanned aerial systems (UAS) to perform surface emissions monitoring for MSW landfills. This method was submitted by Sniffer Robotics, LLC to EPA's Office of Air Quality Planning and Standards Measurement Technology group and was included into the Other Test Method (OTM) category on EPA's Air Emission Measurement Center website on 12/15/2022.

OTM-51 is approved for use at MSW landfills for several federal regulations and is approved for use under this chapter, subject to the caveats and additional information specified in section 11.0 of this appendix.

The following application of OTM-51 is only approved for the purpose of compliance with the surface emission monitoring requirements of this chapter, and does not supersede any approved methods, requirements, or regulations regarding the use of OTM-51 for other federal, state, and local laws or regulations.

2.0 Scope and Application

Scope: This method is an alternative test method for determining compliance with the surface methane operational standard for landfills in lieu of procedures set forth pursuant to WAC 173-408-120 (1)(a).

Analytes

Analyte	CAS Number
Methane (CH_4)	74-82-8

3.0 Summary of Method

This alternative test method seeks to replicate, to the greatest extent possible, EPA Method 21, but automates surface emission monitoring by utilizing a methane detection payload on an "unmanned aerial system (UAS)," as defined in WAC 173-408-020, coupled with a ground level to UAS sampling system. The methane detector payload includes a hose and custom nozzle design that, when carried by the UAS, places the nozzle inlet within 5-10 cm of the ground. The UAS transmits the geolocated methane readings to the operator via a wireless communication system. The UAS is used to sample large areas for "increased meter readings," as defined in WAC 173-408-020, each of which are then inspected using EPA Reference Method 21.

4.0 Equipment and Supplies

(a) The methane detection payload shall have the following specifications:

(i) The methane detection payload shall collect and respond to methane in the air samples; standoff or remote detection technologies are not applicable. Detector types that may meet this requirement include, but are not limited to, flame ionization, nondispersive infrared absorption (NDIR) and tunable diode laser absorption spectroscopy (TDLAS).

(ii) The methane detection payload shall be capable of measuring methane in the range from zero through the increased meter reading up to and above the exceedance limit of 500 ppm specified in this chapter.

(iii) The scale of the methane detection payload shall be readable to ±2.5 percent of the increased meter reading level of 200 ppm methane.

(iv) The methane detection payload shall be equipped with a pump that provides the detector a constant sample flow rate. The nominal sample flow rate, as measured at the sample probe nozzle, shall be at least 0.5 l/min when the probe is fitted with the full impedance stack of tubing, filters, and nozzle.

(v) The methane detection payload shall have a known instrument-only response time. Instrument-only response time shall be measured for the methane detection instrument prior to being placed into service but does not have to be repeated at subsequent intervals. Instrument-only response time shall be measured by measuring the T90 response time for a minimum of five unique tube lengths less than 10m, fitting a linear regression to the measured T90 response times and recording the y-intercept as the instrument only response time if the r^2 of the linear regression is greater than 0.95.

(b) The ground level sampling system shall have the following specifications:

(i) The ground level sampling system shall be equipped with a single nozzle with inside diameter such that the air speed into the nozzle (per the nominal sample flow rate defined in section 4.0(a)(iv) of this appendix) is at least 0.3 m/s.

(ii) The ground level sampling system shall include a hose of sufficient length to drag the nozzle on the ground such that the nozzle is in fluid communication with the methane detection payload.

(iii) Before putting the ground level sampling system into service, determine the "nozzle offset distance," as defined in WAC 173-408-020. If the tube length of the ground sampling density changes or the planned AGL for the ground level sampling system changes, repeat measurements to determine the nozzle offset distance.

(c) The UAS shall have the following specifications:

(i) The UAS shall carry the methane detection payload and the ground level sampling system and use an automated, real-time measurement and control system to fly at a constant AGL of ±1 meter.

(ii) The UAS shall include a data acquisition system to record both timestamped drone position (GPS coordinates with an accuracy of no worse than ±2 meters) and methane concentration. The data shall be logged at a frequency of at least the instrument-only response time per section 4.0(a)(v) of this appendix.

(iii) The UAS shall have a gimbaled camera that is remotely viewable and controllable by a remote operator in near real-time. The camera and display shall have high enough resolution for the operator to discern indicators of elevated concentrations of landfill gas, including distressed vegetation, cracks or seeps in the cover and cover penetrations from the defined flight AGL. Pictures taken shall be georeferenced via metadata or similar to the GPS accuracy of ±2 meters.

(iv) The UAS shall be in communication with an operator display that shows the methane concentration, as measured by the methane detection payload.

(v) If automated flight plans are used to control the path of the UAS, the UAS shall be controllable by the remote operator to deviate from said flight plans to inspect areas where visual observations indicate potential elevated concentrations of landfill gas, such as distressed vegetation, cracks, or seeps in the cover and cover penetrations.

(vi) The UAS shall be equipped with a method to control the forward speed to the value determined to meet the limit under section 7.0 of this appendix.

5.0 Reagents and Standards

(a) Two gas mixtures are required for methane detection payload calibration and performance evaluation:

(i) Zero gas. Air, less than 10 parts per million by volume (ppmv) methane.

(ii) Methane calibration gas. Obtain a known standard in air at a concentration approximately equal to the 500 ppm above background operational limit specified in the regulation.

(b) Cylinder gases: If cylinder calibration gas mixtures are used, they must be analyzed and certified by the manufacturer to be within two percent accuracy, and a shelf life must be specified. Cylinder standards must be either reanalyzed or replaced at the end of the specified shelf life.

6.0 Sample Collection, Preservation, Storage, and Transport

(a) Methane detection payload performance evaluation: Assemble and start up the methane detection payload according to the manufacturer's instructions for recommended warm-up period and preliminary adjustments.

(b) Calibration precision: The calibration precision test shall be completed prior to placing the methane detection payload into service and at subsequent three-month intervals or at the next use, whichever is first.

(i) Make a total of three measurements of both the zero and the methane calibration gas by alternately introducing them where the measurement is collected via the ground level sampling system with all filters, the full tube length, and nozzle present. The introduction of the gas must be done such to not change the flow rate of the system or to pressurize the measurement cell. Record the meter readings.

(ii) Calculate the average algebraic difference between the meter readings and the known value. Divide this average difference by the known calibration value and multiply by 100 to express the resulting calibration precision as a percentage.

(iii) The calibration precision shall be equal to or less than 10.0 percent of the calibration gas value.

(c) Response time: The response time test shall be completed prior to placing the methane detection payload and ground level sampling system into service and at subsequent three-month intervals or at the next use, whichever is first. If a modification to the sample pumping system or flow configuration is made that would change the response time, a new test is required before further use.

(i) Introduce zero gas into the nozzle of the ground level sampling system. When the meter reading has stabilized, switch quickly to the specified calibration gas. After switching, measure the time required to attain 90 percent of the final stable reading. Perform this test sequence three times and record the results. Calculate the average response time.

(ii) The response time shall be equal to or less than 30 seconds. The instrument pump, ground level sampling system with all filters, tubing, and nozzle lengths, which will be used during testing shall all be in place during the response time determination.

(d) Nozzle offset distance: The nozzle offset distance shall be measured prior to placing the methane detection payload into service by recording the time between the UAS passing a known point in space and the nozzle passing the same point in space at a known, consistent speed, hose length and AGL. The horizontal offset distance is the

measured temporal offset of the UAS to the nozzle, multiplied by the known, consistent speed.

(e) Offset calculation: Derive the temporal offset from UAS GPS measurement to receipt of quantified methane measurement for each combination of AGL and methane detection payload configuration by adding the response time to the nozzle offset distance divided by speed. Record this time offset for input to the data acquisition system and offset the reported location of all methane measurements along the actual traversed path by this offset (i.e., if the offset is "X" seconds, the location of the measurement shall be reported as the location of the UAS "X" seconds in the past).

(f) Flow rate: The flow rate test shall be completed prior to placing the methane detection payload and ground level sampling system into service and at subsequent three-month intervals or at the next use, whichever is first. If a modification to the sample pumping system or flow configuration is made that would change the flow rate, a new test is required before further use. Measure the flow rate at the distal end of the collection nozzle with a flow meter readable to at least 0.1 l/min per the flow meter manufacturer's specification. Record the flow rate; the flow rate shall be greater than 0.5 l/min.

(g) Instrument calibration: Calibrate the methane detection payload according to section 10.0 of this appendix.

7.0 Surface Emissions Monitoring via UAS and Follow-up Ground-based Surveys

(a) Set the UAS terrain following system to fly at the constant AGL for the ground level sampling system characterized in section 4.0(b)(ii) of this appendix. Ensure the remote operator can control the gimbaled camera on the UAS and that the resolution is adequate to make visual observations that indicate elevated concentrations of landfill gas, such as distressed vegetation and cracks or seeps in the cover and cover penetrations.

(b) Take off and fly the UAS (at the predefined constant AGL) at a speed such that the instrument-only response time multiplied by the forward flight speed does not exceed four meters along a pattern that traverses the landfill at 25-ft intervals. The aggregation of all the surface sampling traverses shall include the perimeter of the collection area, and all locations where visual observations from the gimbaled camera or aerial imagery taken within 120 days indicate elevated concentrations of landfill gas, such as distressed vegetation and cracks or seeps in the cover.

(i) Surface sampling traverses in accordance with this test method shall only occur during average barometric pressure conditions to the extent possible.

(ii) Surface sampling traverses in accordance with this test method must be terminated when the average wind speed exceeds five miles per hour, or the instantaneous wind speed exceeds 10 miles per hour. Surface testing can continue when the average wind speed is five miles per hour or less. The department or local authority may approve alternatives to this wind speed surface testing termination for MSW landfills consistently having measured winds in excess of these specified limits.

(iii) Surface sampling traverses in accordance with this test method must be conducted only when there has been no measurable precipitation in the preceding 72 hours. The department or local authority may approve alternatives to this procedure for MSW landfills that cannot meet the requirements of this subsection.

(c) During flight, take georeferenced pictures from the UAS gimbaled camera of features that indicate elevated concentrations of landfill gas, such as distressed vegetation and cracks or seeps in the cover and cover penetrations. Inspect these locations per section 7.0(d) of this appendix.

(d) Increased meter readings: If an increased meter reading is observed or recorded by the UAS data acquisition system, refer to Section 8.3.1 of Method 21 to survey the area of the GPS coordinate of the increased meter reading and the area within a radius of at least 15 meters. While inspecting the increased meter readings and traversing the landfill between said increased meter readings, make visual observations to identify areas that indicate elevated concentrations of landfill gas, such as distressed vegetation, cracks or seeps in the cover and cover penetrations and inspect said areas as increased meter readings.

(e) Cover penetrations: In addition to conducting ground-based surveys where increased meter readings were detected, refer to Section 8.3.1 of Method 21 to survey applicable cover penetrations or openings within the landfill area.

(f) Monitoring route: All measurement points compliant with the specifications of this alternative method shall be plotted on a map that encompasses and includes the perimeter of waste. Any points that deviate from this test method including, but not limited to, manual deviations to the AGL that exceed ±1 meter, GPS accuracy worse than ±2 meters, presumed or measured flow rate less than 0.5 l/min, ground sampling density worse than 25-ft intervals, etc. shall not be plotted. Any location on the map greater than 15m from a measurement point shall be noted and justified (e.g., noted as an active area, noted hazards that prevent inspection detail, etc.).

(g) Remonitoring: Refer to EPA Reference Method 21 for remonitoring of previously identified exceedances.

8.0 Exceedances

(a) The owner or operator of a MSW landfill must notify the department or local authority within two working days after all corrective actions and remonitoring taken to address exceedances detected using this method. The notification must include a description of the corrective actions taken. The owner or operator of a MSW landfill may request alternative compliance measures to replace the requirements of this subsection pursuant to WAC 173-408-130.

(b) The owner or operator must record the date, location, and value of each exceedance, along with retest dates and results. The location of each exceedance must be clearly marked and identified on a topographic map, at a minimum, of the MSW landfill, drawn to scale with the location of both the grids and the gas collection system clearly identified.

(c) Corrective action must be taken by the owner or operator such as, but not limited to, cover maintenance or repair, and well vacuum adjustments, and the location must be remonitored within 10 calendar days of a measured exceedance.

(i) If the remonitoring of the location shows a second exceedance, additional corrective action must be taken, and the location must be remonitored again within 10 calendar days of the second exceedance.

(ii) If the remonitoring required by section 8.0(c)(i) of this appendix shows a third exceedance, the owner or operator must install a new or replacement well, or an alternative active methane control

approved by the department or local authority, as needed to achieve compliance no later than 120 calendar days after detecting the third exceedance.

9.0 Quality Control

Section	Quality Control Measure	Effect
6.0 (Calibration Precision)	Instrument calibration precision check	Ensure precision and accuracy, respectively, of instrument response to standard.
10.0	Instrument calibration	

10.0 Calibration and Standardization

(a) Calibrate the methane detection payload as follows: After the appropriate warm-up period and any internal zero calibration procedure, introduce the calibration gas at the inlet of the ground level sampling system to include all filter, tubing, and the nozzle. Per the manufacturer's guidelines ensure the instrument readout corresponds to the calibration gas value within 10.0 percent.

Note: If the meter readout cannot be calibrated to the proper value and/or a malfunction of the methane detection payload is indicated, corrective actions are necessary before use.

11.0 ALT-150 Compliance Letter

The use of OTM-51 for purposes of compliance with this chapter is subject to the following limitations/caveats, as specified in the EPA's ALT-150 letter (dated 12/15/2022):

(a) Entities other than Sniffer Robotics, LLC must submit data comparing OTM-51 and EPA Reference Method 21 to the department or local authority before this alternative test method may be used in lieu of SEM test procedures specified by WAC 173-408-120 (1)(a).

(b) Increased meter readings must be documented as prescribed by OTM-51. When an exceedance of the operational standard is identified, the location of the monitored exceedance must be marked, and the location and concentration recorded as specified in section 8.0 of this appendix. When an increased meter reading is not identified as an exceedance of the operational standard, there must be at a minimum a traditional surface monitoring pattern either in a spiral or serpentine pattern with three-meter intervals that covers a 30-meter radius from the increased meter readings to confirm no exceedance of the operational standard.

(c) Affected landfills using OTM-51 must notify the department or local authority before use of this alternative method and notification must include a copy of this appendix.

(d) Landfills must include a copy of this appendix and method with each report presenting SEM results using OTM-51.

(e) Once an owner or operator of a landfill chooses to use OTM-51, the landfill must continue to use the alternative method in meeting the requirements of this chapter until the owner or operator receives approval from the department or local authority to return to the existing Method 21 or use of a new EPA-test method.

[Statutory Authority: Chapter 70A.540 RCW. WSR 24-11-052 (Order 22-15), § 173-408-990, filed 5/13/24, effective 6/13/24.]