New Jersey Department of Environmental Protection
Division of Air Quality, Bureau of Stationary Sources

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State of the Art (SOTA)Manual for Equipment Used to Vent Municipal Solid Waste Landfills

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Section 3.18 - State of the Art (SOTA)
Manual for Equipment Used to Vent Municipal Solid Waste Landfills

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3.18 MANUAL FOR EQUIPMENT USED TO VENT MUNICIPAL SOLID WASTE LANDFILLS

3.18.0 Definitions

"Instantaneous surface monitoring" means equipment and processes used to obtain a value at the time of measurement for an ambient air contaminant concentration above the background air contaminant concentration. Air contaminants that may be monitored include methane and hydrogen sulfide (H_2S). Such monitoring may include taking a sample 0-3 inches above the landfill with a portable flame ionization detector that provides real-time values of methane concentration.

"Integrated surface monitoring" means equipment and processes used to determine the air contaminant concentration for a set number of spatial grids. Such monitoring may include collecting samples of ambient air 0-3 inches above the landfill over an 8- to 10-hour period and having the sample analyzed for methane concentration.

"Landfill" means an area of land or an excavation in which wastes are placed for permanent disposal, and that is not a land application unit, surface impoundment, injection well, or waste pile.

"Landfill Gas (LFG)" means the air contaminants generated by the anaerobic (without oxygen) decomposition of organic wastes in a landfill. LFG commonly contains greenhouse gases (GHG), including carbon dioxide (CO_2) and methane; hazardous air pollutants (HAPs), hydrogen chloride (HCl) and mercury; H_2S; siloxanes (compounds containing silicon, hydrogen, and oxygen); and volatile organic compounds (VOCs).

"Non-Methane Organic Compounds (NMOC)" means VOC and other organic compounds, excluding methane. NMOC is the term to report organic compound emissions for landfills, using U.S. Environmental Protection Agency (EPA) Reference Methods 25 or 25C.

"Municipal Solid Waste (MSW) Landfill" means an entire disposal facility in a contiguous geographical space where household waste is placed in or on land. An MSW landfill may also receive other types of wastes, such as commercial solid waste, nonhazardous sludge, conditionally exempt small quantity generator waste, and industrial solid waste. Portions of an MSW landfill may be separated by access roads. An MSW landfill may be publicly or privately owned. An MSW landfill may be a new MSW landfill, an existing MSW landfill, or a lateral expansion.

"Pipeline Quality Natural Gas" means a natural gas that is merchantable and marketable that meets an interstate or intrastate transmission company's minimum specifications with respect to:

(i) delivery pressure;
(ii) delivery temperature;
(iii) heat content in British Thermal Units (BTU);
(iv) mercaptan sulfur;
(v) total sulfur;
(vi) moisture and/or water content;
(vii) CO_2;
(viii) oxygen (O_2);

(ix) total inerts (the total combined CO_2, helium, nitrogen, O_2, and any other inert compound percentage by volume);
(x) hydrocarbon dew point limits;
(xi) merchantability;
(xii) content of any liquids at or immediately downstream of the delivery point into a pipeline; and
(xiii) interchangeability with the typical composition of the gas in the pipeline with respect to the following indices: Wobbe Number, Lifting Index, Flashback Index, and Yellow Tip Index per AGA Bulletin No. 36.

"Renewable Natural Gas (RNG)" means LFG that has been processed to remove impurities and increase methane concentration to meet the requirements for pipeline quality natural gas.

3.18.1 Scope

These State-of-the-Art (SOTA) performance levels apply to all equipment used for the purpose of venting a closed or operating municipal solid waste (MSW) landfill, directly or indirectly into the outdoor atmosphere which are subject to the SOTA provisions of the New Jersey Administrative Code (N.J.A.C.) 7:27-8 and N.J.A.C. 7:27-22. When accounting for the emissions to determine SOTA applicability, the potential to emit (PTE) emissions for the equipment used for the purpose of venting a MSW landfill should include, but may not be limited to, all collected air contaminant emissions that are discharged through a stack through passive or active venting and all uncollected air contaminant emissions that are not emitted to the atmosphere through a stack (fugitive emissions). Additional sources of air pollution can include leachate storage tanks, tub grinders and fugitive dust from unpaved roadways and activities at the landfill face. Associated operations, including processing or combustion of landfill gas (LFG) that may not be under the common control or ownership of the landfill, are included in this SOTA.

The SOTA thresholds for source operations, which must obtain a Preconstruction Permit pursuant to N.J.A.C. 7:27-8, can be found in:

1. N.J.A.C. 7:27-8, Appendix 1, Table A for criteria pollutants; and
2. N.J.A.C. 7:27-17.9, Tables 3A and 3B for hazardous air pollutants (HAPs) and toxic substances (TXS) regulated by the New Jersey Department of Environmental Protection (the Department).

The SOTA thresholds for source operations which must obtain an Operating Permit, pursuant to N.J.A.C. 7:27-22 can be found in:

1. N.J.A.C. 7:27-22, Appendix, Table A; and
2. N.J.A.C. 7:27-17.9, Tables 3A and 3B for HAP and TXS.

If a source operation was omitted in this manual, the applicant shall represent SOTA technology using a case-by-case approach, if applicable, pursuant to N.J.A.C. 7:27-8.12 and N.J.A.C. 7:27-22.35. For air contaminants that may be emitted from the sources described in this manual, but for which a performance level is not specified, SOTA will be done on a case-by-case basis pursuant to N.J.A.C. 7:27-8, N.J.A.C. 7:27-22, and Section 1.5 Case-by-Case SOTA in the General State of the Art Manual available at https://dep.nj.gov/boss/state-of-the-art/.

This SOTA Manual includes SOTA standards from LFG combustion in engines and turbines. Additional SOTA standards can be found in the SOTA Manual for Reciprocating Internal Combustion Engines - Section 3.13 and SOTA Manual for Stationary Combustion Turbines - Section 3.14.

For odor control guidance see Guidance on Preparing an Air Quality Modeling Protocol (1002). This document is available at https://dep.nj.gov/boss/technical-manuals/. For the use of odor neutralizers or deodorants at landfills, refer to the Use of Odor Neutralizers at Landfills.

3.18.2 SOTA Performance Levels

This SOTA includes operational requirements, emissions limitations, and control efficiency requirements for different air contaminants, depending on the size of the MSW landfill and annual emissions rate of non-methane organic compounds (NMOC) from the MSW landfill.

3.18.2.1 Maximum Achievable Control Technology for MSW Landfills

For HAP emissions from applicable MSW landfills, compliance with the provisions of the Maximum Achievable Control Technology (MACT) standard found in Title 40 of the Code of Federal Regulations (CFR), Part 63, Subpart AAAA, National Emission Standards for Hazardous Air Pollutants (NESHAP): Municipal Solid Waste Landfills[1] is considered equivalent to SOTA, pursuant to N.J.A.C. 7:27-8.12(e)(3) for preconstruction permits and N.J.A.C. 7:27-22.35(c) for operating permits. Emissions of other air contaminant emissions from MSW landfills not subject to the MACT standard are addressed in other sections of this SOTA manual.

MSW landfills that accepted waste since November 8, 1987, or have additional capacity for waste deposition and meet any of the following applicability requirements are subject to the MACT standard:

1. MSW landfill is a major source of HAP;
2. MSW landfill is an area source of HAP co-located with a major source of HAP; or
3. MSW landfill is an area source of HAP with a design capacity equal to or greater than 2.5 million megagrams (Mg) or 2.75 million tons AND 2.5 million cubic meters (m^3) or 3.26 million cubic yards AND an NMOC emission rate greater than 50 Mg per year (55 tons per year - tpy).[2]

3.18.2.2 Emissions Guidelines for MSW Landfills Existing Before July 18, 2014

The U.S. Environmental Protection Agency (EPA) has developed requirements in 40 CFR, Part 62, Subpart OOO for MSW landfills that have not been modified or reconstructed since July 18, 2014. If these MSW landfills accepted waste since November 8, 1987, or have additional capacity for waste deposition, they are subject to 40 CFR, Part 62, Subpart OOO. The regulation includes emissions limits and control requirements for MSW landfills that meet either of the following applicability requirements:

[1] Title 40 of the Code of Federal Regulations, Part 63, Subpart AAAA.
[2] Title 40 of the Code of Federal Regulations, Part 63, Subpart AAAA.

1. MSW landfill with a design capacity of 2.5 million Mg (2.75 million tons) AND 2.5 million cubic meters (3.26 million cubic yards) AND an NMOC emission rate greater than or equal to 34 Mg per year (37 tpy); or
2. MSW landfill with a design capacity of 2.5 million Mg (2.75 million tons) AND 2.5 million cubic meters (3.26 million cubic yards) AND Tier 4 surface emissions monitoring shows a methane concentration of 500 parts per million (ppm) or more.

MSW landfills subject to 40 CFR, Part 62, Subpart OOO must install an active or passive LFG collection and control system that routes all collected LFG to a control system that meets any one of the following requirements:

1. Non-enclosed flare that meets the requirements specified in 40 CFR §60.18(b) and no visible emissions except for 5 minutes during any consecutive 2-hour period, (as measured using EPA Reference Method 22);
2. A control system designed and operated to reduce NMOC 98% by weight;
3. An enclosed control system designed and operated to achieve an NMOC outlet concentration of less than 20 ppm by volume on a dry basis (ppmvd) as hexane at 3% oxygen (O_2); or
4. A treatment system for processing the collected LFG for subsequent sale or use. Any venting of collected LFG from the treatment system must still meet the requirements for a control system (i.e., flare or other NMOC control system).[3]

Atmospheric vents on condensate tanks are not required to be vented to the control system. The treatment system for collected LFG is the responsibility of and must remain in control of the landfill owner or operator.

Note: *Although 40 CFR, Part 62, Subpart GGG applies to MSW Landfills constructed before May 30, 1991, and 40 CFR, Part 60, Subpart WWW applies to MSW landfills constructed after May 29, 1991, the requirements of 40 CFR, Part 62, Subpart OOO are more stringent than both regulations.*

3.18.2.3 New Source Performance Standards for New or Modified MSW Landfills

EPA has developed requirements in 40 CFR, Part 60, Subpart XXX for MSW landfills that were constructed or reconstructed after July 17, 2014. The regulation includes emissions limits and control requirements for MSW landfills that meet either of the following applicability requirements:

1. MSW landfill with a design capacity of 2.5 million Mg (2.75 million tons) AND 2.5 million cubic meters (3.26 million cubic yards) AND an NMOC emission rate greater than or equal to 34 Mg per year (37 tpy); or
2. MSW landfill with a design capacity of 2.5 million Mg (2.75 million tons) AND 2.5 million cubic meters (3.26 million cubic yards) AND Tier 4 surface emissions monitoring shows a methane concentration of 500 ppm or more.

The requirements for MSW landfills subject to 40 CFR, Part 60, Subpart XXX are the same as the requirements listed in 40 CFR, Part 62, Subpart OOO, included in 3.18.2.2.

[3] Title 40 of the Code of Federal Regulations, Part 62, Subpart OOO.

3.18.2.4 Other SOTA Performance Levels for MSW Landfills

A. For MSW Landfills subject to the applicability requirements of 40 CFR, Part 60, Subpart XXX (for new landfills) or 40 CFR, Part 62, Subpart OOO (for existing landfills), the following additional requirements apply:

1. Install a LFG collection system that routes all collected LFG to a control device. The LFG collection and control system can have no LFG leaks. A LFG leak would be measured at 500 ppm by volume (ppmv) above background, (as methane) as an instantaneous reading that can be repeated and documented at least two times within 5 minutes, and/or 25 ppmv average above background (as methane) from integrated surface emissions monitoring, and that meets any of the following requirements:
   a. Enclosed combustor or enclosed flare that achieves a methane destruction efficiency of 99% for NMOC;[4]
   b. A control system designed and operated to reduce methane 99% by weight;[5]
   c. A lean burn internal combustion engine that meets an outlet methane concentration of 7,067 ppmvd at 7% O_2;[6] or
   d. A treatment system for processing the collected LFG for subsequent sale or use. Any venting of collected LFG from the treatment system must still meet the requirements for a control system (i.e., enclosed combustor / flare or other NMOC control system).[7]
2. No location on the MSW landfill surface can exceed 500 ppmv above background (as methane), as a repeatable reading, using instantaneous surface emissions monitoring for methane. Satisfaction of this requirement presumes the adequacy of the LFG collection system. Methane is used as a surrogate for monitoring and control of VOC / NMOC. If methane leaks are detected above 500 ppmv, the landfill operator shall employ corrective action and demonstrate methane detection is at or below 500 ppmv. Repeat monitoring will be conducted 10 days and 30 days after corrective actions are employed. Documentation for NJ DEP review.[8]

B. Sulfur dioxide (SO_2) emissions limits and control requirements for MSW landfills:
1. For collected LFG with a hydrogen sulfide (H_2S) concentration greater than 10,000 ppmv, a minimum 98% removal of all sulfur compounds, extracted by the LFG system prior to the combustion device; OR
2. For collected LFG with an H_2S concentration less than or equal to 10,000 ppmv, SO_2 emissions from the combustion device exhaust shall not exceed 200 ppmv. Compliance with this provision will be provided by monitoring of the H_2S concentration (assuming 200 ppmv H_2S is converted into 200 ppmv SO_2 by the combustion unit) in the gas stream before any combustion controls (e.g., flare).[9]

C. H_2S emissions limits for MSW landfills:

[4] Title 17 of the Code of California Regulations, §95464(b)(2)(A)
[5] Oregon administrative Rule (OAR) 340-239-0010(2)(b)(A)
[6] Title 17 of the Code of California Regulations, §95464(b)(3)(A), converted from 3,000 ppmvd at 15% O_2
[7] Title 17 of the Code of California Regulations, §95464(b)(3)(B)
[8] Title 17 of the Code of California Regulations, §95464(b)(1)
[9] Permit-to-Install P0128797 issued on December 1, 2021, to Sunny Farms Landfill

1. The Department may require the owner or operator to design and install an H_2S ambient air monitoring system based upon its determination that the sanitary landfill is the source of H_2S emissions that result in a violation of N.J.A.C.7:27-5.2 or an exceedance of the hydrogen sulfide standard at N.J.A.C. 7:27-7.3.

D. Emissions limits for enclosed combustor / flare:
   1. Carbon Monoxide (CO): 0.010 pounds (lbs.)/MMBtu;
   2. Nitrogen Oxides (NO_X): 0.05 lbs./MMBtu;
   3. Total Suspended Particulates (TSP): 0.020 lbs./MMBtu; and
   4. Opacity: 10%, as a 6-minute average.

E. Emissions limits for lean burn engines:
   1. A lean burn internal combustion engine that meets an outlet methane concentration of 7,067 ppmvd at 7% O_2; and
   2. Additional emissions limitations and control requirements for reciprocating internal combustion engines are included in Section 3.13, 40 CFR, Part 60, Subpart IIII, and 40 CFR, Part 63, Subpart ZZZZ.

F. Below are the emissions limits and restrictions for open and/or candlestick flares. They may be operated during the repair/maintenance of the enclosed combustor/flare, and/or low flow conditions of the landfill.[10] Low LFG flow is defined as any LFG flow outside of the flow design parameters of the primary control device.
   1. CO: 0.2 lbs./MMBtu;
   2. NO_X: 0.06 lbs./MMBtu;
   3. TSP: 0.06 lbs./MMBtu; and
   4. 500 hours of operation annually for low LFG flow episodes, testing, and maintenance.

   An air permit modification may be required for situations where the continued use of open / candlestick flares is necessary.

   Operation during emergencies (as defined below) is not restricted or subject to any hourly operational limitations. However, the Department's regional Enforcement Office must be notified promptly regarding emergencies under which open / candlestick flares must be used.

   Emergencies are limited to situations that arise from sudden and reasonably unforeseeable events beyond the control of an owner or operator of a facility, such as an unforeseen system capacity shortage, that requires immediate corrective action to prevent system collapse or to restore normal operations at the facility.

G. Siloxane treatment system (if employed):
   1. For engines: the engine manufacturer, operator, or owner shall establish the maximum siloxane concentration, to be measured at the outlet of the siloxane treatment system. Alternatively, the engine operator may opt to establish a more stringent maintenance cycle for engines to remove siloxane buildup.
   2. For processing LFG for subsequent sale or use: siloxane concentration must be reduced to satisfy the requirements of pipeline quality natural gas, or any additional standards

[10] NJDEP Technical Manual 1006: Municipal Solid Waste Landfills Air Permitting Guidance

established by the natural gas pipeline operator.

3. Siloxane concentration in LFG shall be determined using a continuous analyzer or by monthly sampling using a method specified by the engine manufacturer or pipeline operator, ASTM Method D8455-22, or ASTM Method D8230-19.

H. For landfills not subject to the applicability requirements of 40 CFR, Part 60, Subpart XXX (for new landfills) or 40 CFR, Part 62, Subpart OOO (for existing landfills), conduct a case-by-case SOTA analysis pursuant to N.J.A.C. 7:27-8.12(f), for minor facilities, or N.J.A.C. 7:27-22.35(c)5, for major facilities, and Section 1.5 Case-by-Case SOTA in the General State of the Art Manual available at https://dep.nj.gov/boss/state-of-the-art/.

3.18.2.5 Alternate Control Technologies – Beneficial Uses of Landfill Gas

Due to its relatively high concentration of methane and other hydrocarbons, LFG can be processed to remove impurities in a similar manner as natural gas. LFG can be processed into renewable natural gas (RNG) or compressed natural gas (CNG), a common fuel alternative to gasoline or diesel fuel. To successfully process LFG into CNG/RNG, impurities must be removed, and the methane content increased. LFG impurities include carbon dioxide (CO_2) and sulfur compounds, water, and siloxanes, (silica-containing compounds commonly found in shampoo, cosmetics, and detergents). The methane content is increased by removing other hydrocarbons from the processed LFG.

Conversion of LFG into CNG/RNG includes the following processes:

1. Siloxane removal by refrigeration, adsorption, or absorption;
2. Sulfur and CO_2 removal by amine treatment, chemical reaction, adsorption, or absorption;
3. Water removal by absorption or filtering;
4. Nitrogen and oxygen removal by filtering; and
5. Increasing methane concentration by liquid fractionation.

Siloxane treatment systems are required to remove siloxane from the LFG, as it breaks down during combustion to form silica (SiO_2) and silicate deposits in combustion chambers, exhaust manifolds, and exhaust stacks. Siloxane buildup on cylinder heads and pistons reduces cylinder volume and increases the compression ratio of an engine, increasing cylinder pressures and CO emissions. Reduced sulfur compounds such as H_2S, methyl mercaptan (CH_3SH), dimethyl sulfide ($(CH_3)_2S$), carbon disulfide (CS_2), and dimethyl disulfide ($(CH_3)_2S_2$) are formed within the landfill and increase SO_2 emissions when combusted. Higher H_2S concentrations in combusted LFG cause increased wear and corrosion of engine parts. Routine emissions testing for CO, NMOC, and SO_2 needs to be conducted on engines combusting LFG to ensure that the engine is performing with specifications.

Because of the variability and different emissions profiles for sulfur, water, and hydrocarbon removal equipment in LFG processing systems, any MSW landfill using treatment systems must undergo a case-by-case SOTA analysis pursuant to N.J.A.C. 7:27-8.2(f), for minor facilities, or N.J.A.C. 7:27-22.35(c)5, for major facilities, and Section 1.5 Case-by-Case SOTA in the General State of the Art Manual available at https://dep.nj.gov/boss/state-of-the-art/.

3.18.3 Technical Basis

The basis for developing this SOTA was information from the following sources:

A. Title 40 of the Code of Federal Regulations, Part 60, Subpart XXX, "Standards of Performance for Municipal Solid Waste Landfills That Commenced Construction, Reconstruction, or Modification After July 17, 2014."

B. Title 40 of the Code of Federal Regulations, Part 62, Subpart OOO, "Federal Plan Requirements for Municipal Solid Waste Landfills That Commenced Construction on or Before July 17, 2014, and Have Not Been Modified or Reconstructed Since July 17, 2014."

C. Title 40 of the Code of Federal Regulations, Part 63, Subpart AAAA, "National Emission Standards for Hazardous Air Pollutants: Municipal Solid Waste Landfills."

D. State of California, Air Resources Board, Final Regulation Order, Title 17 of the Code of California Regulations, Subchapter 10, Article 4, Subarticle 6. Methane Emissions from Municipal Solid Waste Landfills.

E. SC&A, Inc. *Analysis of Landfill Permits Emissions Limits and Control Requirements*, August 22, 2022.

3.18.4 Recommended Review Schedule

This technical manual will be reviewed periodically and revised if new collection and control technologies that minimize emissions become available, and any time a new MACT standard or standard of performance for new or existing sources is published.