

BACKGROUND DOCUMENT

GENERAL PLAN APPROVAL AND/OR GENERAL OPERATING PERMIT (BAQ-GPA/GP-22)

Landfill Gas-fired Simple Cycle Turbines

EXECUTIVE SUMMARY

The Pennsylvania Department of Environmental Protection (Department) is developing a new General Permit to authorize construction or modification and operation of landfill gas-fired turbines.

Authorization will also be granted under this General Permit for operation of permitted landfill-gas fired turbine(s) replacement with an identical “turbine core” (combustor, compressor, and turbine section). This replacement must not alter the capacity of the equipment, nor result in any increase in air pollution emission rates for the turbine(s) and shall be recommended and performed by the turbine vendor and otherwise used in the turbine industry.

INTRODUCTION

Landfilling is a method to dispose of solid wastes on land. When a landfill is capped, landfill gas (LFG) is generated as organic portions of the municipal solid wastes (MSW) decompose. The organic portions of the MSW in a landfill, including paper and paperboard, yard wastes and food wastes, decompose through biochemical reactions when an anaerobic condition exists. This produces landfill gas. In general, landfill gas contains 50% methane (CH₄), 45% carbon dioxide (CO₂), and also other gases, such as nitrogen (N₂), oxygen (O₂), hydrogen sulfide (H₂S) and water vapor (H₂O).

Instead of burning and venting the gas directly into the atmosphere, it may be directed to a combustion system, which either uses the heat from burning the gas directly or supplies the gas to a reciprocating engine or turbine to produce electricity.

PLAN APPROVAL PROCESS

As required under Section 6.1 of the Pennsylvania Air Pollution Control Act (“APCA”) and its implementing regulations, the Department issues air quality plan approvals and operating permits for air contamination sources, including landfill gas-fired turbines.

Chapter 127 of *25 Pa. Code* requires that all new or modified landfill gas-fired turbines shall control the emissions to the maximum extent, consistent with the Best Available Technology (BAT) as determined by the Department at the time of the issuance of the plan approval. Applications are reviewed for BAT requirements on a case-by-case basis, which may take from 90 to 180 days depending on the type of facility, number of

turbines located at the facility, and complexity of regulatory requirements for each turbine. The Department acknowledges the need to quickly authorize construction and/or operation of landfill gas-fired turbines.

GENERAL PERMIT

A General Permit is a pre-approved plan approval and/or operating permit, which applies to a specific class of sources in a category that are similar and can be adequately regulated using standardized specifications and conditions. By issuing a General Permit, the Department approves the activities authorized by the General Permit, provided that the owner or operator of the source notifies the Department and meets the emission limits and other terms and conditions of the permit. General permits are best suited for regulating similar source categories. They assist in providing consistent requirements.

Authorization to construct and operate under this General Permit emphasizes streamlining the process by using a simplified application and issuance process. *25 Pa. Code* §127.621 requires the Department to take action on the application submitted for use of a general plan approval and general operating permit within 30 days of receipt. This General Permit would provide a streamlined alternative to permitting for pre-construction authorization of landfill gas-fired turbines, while implementing emission limitations for these turbines.

Facilities that cannot meet the General Permit conditions may apply to the Department for a plan approval and/or an operating permit in accordance with *25 Pa. Code* Chapter 127, Subchapter B (relating to plan approval requirements) and/or Subchapter F (relating to operating permit requirements).

GENERAL PERMIT CONDITIONS ANALYSIS AND JUSTIFICATION

Description

This General Permit requires landfill gas-fired turbines to comply with regulatory requirements, such as recordkeeping, including emissions limits, for Nitrogen Oxides (NO_x), Carbon Monoxide (CO), Total Hydrocarbons (THC), Non-Methane Organic Compounds (NMOC), Sulfur Dioxide (SO₂) and Particulate Matter (PM). This General Permit will be valid for five years. The Permittee's right to operate under this General Permit will be terminated on the date of expiration of the authorization to operate, unless a timely and a complete renewal application is submitted to the Department 30 days prior to the permit expiration date.

Applicability

This General Permit applies to new units and also existing units that are modified after the effective date. It also applies to the operation of a permitted landfill-gas fired turbine(s) with a replacement "turbine core" (combustor, compressor, and turbine section) with identical components. This replacement must not alter the capacity of the

equipment, nor result in any increase in air pollution emission rates for the turbine(s) and shall be recommended and performed by the turbine vendor and otherwise used in the turbine industry. It is not intended to require existing permitted turbines to meet the emissions rates and other terms and conditions of this General Permit unless modified.

Turbine Core Replacement Requirements

Consistent with a settlement reached in the case *Tennessee Gas Pipeline Co. v. DEP*, (Docket number 2005-261) the Department has provided an exemption from Plan Approval in the General Permit for any replacement of the turbine core of a turbine compression engine with an identical turbine core or a lower emitting turbine core. Such replacements of the turbine core would only be allowed provided the requirements listed in Condition 6 of the General Permit are met. The Department and the company agreed to this settlement in the form of a consent adjudication that provides, among other things, turbine core replacements may occur for no more than fifteen (15) years after which a plan approval application and best available technology evaluation must be submitted to the Department for its review and approval. Notice of settlement in form of consent adjudication was published in the Pennsylvania Bulletin on July 1, 2006. 36 Pa.B. 3354. No comments were received on this consent adjudication.

A permittee applying for a replacement of the turbine core of a turbine compression engine that does not meet the requirements of Condition 6 shall apply for a plan approval that meets the requirements of 25 Pa. Code, Chapter 127, Subchapter B.

Notification Requirements

Condition 7 of the General Permit establishes requirements for applications and notifications required by 25 Pa. Code §127.621. As required under § 127.621(b), the application shall be either hand delivered or transmitted by certified mail. Condition 7 also outlines the notification requirements for any malfunctioning of landfill gas-fired turbine(s).

Air Pollution Emissions Limits

Condition 8 establishes the emission standards for landfill gas-fired turbines installed after July 1, 1972.

NO_x Emissions

Oxides of nitrogen (NO_x) are formed by high temperature reaction between oxygen and nitrogen in air. Burning of carbon-based fuels such as landfill gas in air generates a high temperature condition wherein the oxygen/nitrogen reaction can occur. High temperatures generally exist outside the area of combustion, in combustor regions where temperatures are sufficiently high to promote oxygen/nitrogen reaction. The rate of thermal NO_x formation through fixation of atmospheric molecular nitrogen depends strongly on the peak flame temperature and residence time in the primary zone of the

combustor. Any technology that allows temperatures in the combustion areas to remain high, yet reduce the temperature in other combustor regions, will result in lower NO_x production.

NO_x Control Technologies

The following technologies were evaluated for control of NO_x emissions from landfill gas-fired turbines.

Dry Low NO_x Combustor (DLNC)

The manufacturers of landfill gas turbines have not developed a dry low NO_x burner because of the small potential market. Therefore, DLNC burners are not technologically feasible because they do not exist for landfill gas applications.

Water or Steam Injection

Because of the presence of inert gases in landfill gas, the flame temperature is low compared to natural gas applications. Since it is not justifiable to incorporate water or steam injection systems into a landfill turbine for an “incremental” NO_x reduction while risking mechanical failure of the turbine, landfill gas turbine manufacturers do not recommend water or steam injection as a feasible NO_x control option.

Central Contra Costa Sanitary District (CCCSD) installed a Solar Centaur T-4700, 3500 KW (49.5 MMBtu/hr) turbine with a water injection system. Upon further review, it was found that the turbine was permitted at 42 ppmvd at 15% oxygen and water injection was never used to meet this limit.

Vasco Road Landfill proposed a NO_x limit of 35 ppmvd corrected to 15% oxygen for their landfill gas-fired turbine. However, the Bay Area Air Quality Management District (BAAQMD) concluded that water injection is a feasible option for landfill gas-fired turbines and established a NO_x emission standard of 25 ppmvd corrected to 15% oxygen. Vasco Road Landfill responded that the vendor would not guarantee successful operation of water injection in the turbine and subsequently terminated the project.

The Department couldn't locate a landfill gas-fired turbine operating with a water or steam injection system. Therefore, water or steam injection control is excluded from BAT determination.

Selective Catalytic Reduction (SCR)

Siloxanes are commercially produced, man-made compounds commonly found in deodorant, cosmetics, and lubricants. When these products are discarded in landfills, they break down into a gaseous compound containing methane, silica, and oxygen. Combustion of landfill gas containing siloxane compounds produces a fine silica powder that deposits on the catalyst and causes masking of the catalyst. This makes SCR impractical in landfill gas

applications. Siloxane concentrations can vary appreciably within different landfills and have been measured from as low as 0.2 ppmvd to almost 10 ppmvd. The siloxane compounds found in the landfill gas at the Calabasas Landfill include the following:

- Hexamethylcyclotrisiloxane (D3)
- Octamethylcyclotetrasiloxane (D4)
- Decamethylcyclopentasiloxane (D5)
- Hexamethyldisiloxane (L2)

Removal of siloxane compounds prior to the introduction of gas into the landfill gas-fired turbine may be possible, but this technology hasn't been demonstrated in practice and may become cost-prohibitive because siloxane concentrations can be as low as 0.2 ppmvd.

The Department has not identified any actual installation of SCR on landfill gas projects and therefore excluded SCR technology from BAT determination.

Based on the above, no additional control is technically or economically feasible for landfill gas-fired turbines.

BAT for NO_x Emissions

In order to determine the lowest feasible uncontrolled NO_x emission rate, the Department reviewed the following several actual stack test results for various uncontrolled landfill gas-fired turbines:

Pottstown Landfill

Turbine No. 1.

Parameter	1 7/31/1989	2 7/31/1989	3 7/31/1989	Average
NO _x as NO ₂ ppmvd @ 15% O ₂	24.9	25.8	27.4	26.0

Turbine No. 1.

Parameter	1 09/30/03	2 09/30/03	3 10/01/03	Average
NO _x as NO ₂ ppmvd @ 15% O ₂	23.8	24.4	23.4	23.9

Turbine No. 1.

Parameter	1 5/14/2004	2 5/14/2004	3 5/14/2004	Average
NO _x as NO ₂				

ppmvd @ 15% O ₂	27	34	30	30
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Turbine No. 2.

Parameter	1 7/31/1989	2 7/31/1989	3 7/31/1989	Average
NO _x as NO ₂ ppmvd @ 15% O ₂	26.8	27.7	27.6	27.3

Turbine No. 2.

Parameter	1 09/30/03	2 09/30/03	3 10/01/03	Average
NO _x as NO ₂ ppmvd @ 15% O ₂	25.4	26.7	27.4	26.5

Turbine No. 2.

Parameter	1 5/14/2004	2 5/14/2004	3 5/14/2004	Average
NO _x as NO ₂ ppmvd @ 15% O ₂	27	28	27	27.3

Green Knight Economic Development Corp

Turbine No. 1.

Parameter	1 11/15/03	2 11/15/03	3 11/15/03	Average
NO _x ppmvd @ 15% O ₂	27.58	28.07	27.94	27.9

Turbine No. 2.

Parameter	1 11/14/03	2 11/14/03	3 11/14/03	Average
NO _x ppmvd @ 15% O ₂	29.41	29.14	29.14	29.23

Omega Hills, Wisconsin Landfill

Turbine No. 1.

Parameter	1 4/17/86	2 4/17/86	3 4/17/86	Average
NO _x ppmvd @ 15% O ₂	24.7	21.7	25	23.8

Turbine No. 2.

Parameter	1 4/18/86	2 4/18/86	3 4/18/86	Average
NO _x ppmvd @ 15% O ₂	30.57	30.42	29.21	30.07

Metro, Wisconsin Landfill

Turbine No. 1.

Parameter	1 4/15/86	2 4/15/86	3 4/15/86	Average
NO _x ppmvd @ 15% O ₂	32.15	39.06	30.58	33.93

Lake, Illinois Landfill

Turbine No. 1.

Parameter	1 9/1/88	2 9/1/88	3 9/1/88	Average
NO _x ppmvd @ 15% O ₂	35.3	36.2	35.4	35.6

Turbine No. 2.

Parameter	1 8/31/88	2 8/31/88	3 8/31/88	Average
NO _x ppmvd @ 15% O ₂	36.2	33.3	37.1	35.5

Altamont Electric Company, CA

Turbine No. 1.

Parameter	1 10/4/94	2 10/4/94	3 10/4/94	Average
NO _x ppmvd @ 15% O ₂	29.83	27.84	28.14	28.6

Turbine No. 2.

Parameter	1 10/4/94	2 10/4/94	3 10/4/94	Average
NO _x ppmvd @ 15% O ₂	27.9	28.8	29.36	28.7

In addition to the above stack test results for NO_x emissions, the Department also analyzed more than 100 stack test results for NO_x emissions from various landfill gas-fired turbines provided by Waste Management. Most of these test runs were performed during a full load turbine operation and in 86% of the cases the turbines were able to meet NO_x emissions at lower than 35 ppmvd corrected to 15% oxygen.

As mentioned in the above tables and stack test data for NO_x emissions provided by Waste Management, landfill gas-fired turbine emissions of NO_x range from 23.8 to 35.6 ppmvd corrected to 15% oxygen. NO_x emissions from these landfill gas-fired turbines vary because NO_x emissions from landfill gas-fired turbines are mostly dependent on the composition of the landfill gas and associated heating value and not on the turbine type. The heating value of landfill gas ranges from 350 to 500 Btu/cubic feet LHV, but typically the heating value is approximately 450 Btu/cubic feet LHV. Fuel variability must be taken into account while establishing a NO_x emission rate that could be

achievable by all landfill gas turbines. In addition to fuel variability, ambient temperature, relative humidity, turbine operating load levels, site elevation, inlet and outlet losses, and specific turbine design will also affect the NO_x emissions from landfill turbines. Therefore, the Department has decided to add at least 20% buffer in 35 ppmvd emission rate as it can be achieved by any landfill gas-fired turbine on a consistent basis.

BAT Determination

Based on the above, a NO_x emission rate of 42 ppmvd corrected to 15% oxygen is achievable in practice and is considered as BAT for NO_x for landfill gas-fired turbine(s). An allowable emissions level of 42 ppmvd corrected to 15% oxygen can be achieved by landfill gas turbines operating with good combustion practices.

BAT for CO Emissions

CO Control Technologies

Oxidation Catalyst

An oxidation catalyst is typically used to control CO emissions from large natural gas-fired turbines. However, as indicated above, the presence of Siloxanes in landfill gas causes masking of the catalyst. Therefore, catalysts have been demonstrated to be impractical in landfill gas applications. The Department has not identified any actual installation of CO catalysts on landfill gas projects. However, good operating and maintenance practice may reduce CO emissions to a certain level and was decided to be BAT.

In order to determine the lowest feasible uncontrolled CO emission rate, the Department reviewed the following actual stack test results for various uncontrolled landfill gas-fired turbines:

Stack Test Results

Pottstown Landfill

Turbine No. 1.

Parameter	1 9/30/2003	2 9/30/2003	3 10/01/2003	Average
CO ppmvd @ 15% O ₂	46.52	43.92	35.2	41.9

Turbine No. 1.

Parameter	1 5/14/2004	2 5/14/2004	3 5/14/2004	Average
CO ppmvd @ 15% O ₂	21	21	23	22

Turbine No. 2.

Parameter	1 9/30/2003	2 9/30/2003	3 10/01/2003	Average
CO ppmvd @ 15% O ₂	50	48.3	52.1	50.1

Turbine No. 2.

Parameter	1 5/14/2004	2 5/14/2004	3 5/14/2004	Average
CO ppmvd @ 15% O ₂	25	23	23	24

Green Knight Economic Development Corp

Turbine No. 1.

Parameter	1 11/15/2001	2 11/15/2001	3 11/15/2001	Average
CO ppmvd @ 15% O ₂	39.4	37.9	44.3	40.5

Turbine No. 2.

Parameter	1 11/14/2001	2 11/14/2001	3 11/14/2001	Average
CO ppmvd @ 15% O ₂	49.3	40.3	41.7	43.8

Turbine No. 3.

Parameter	1 11/13/2001	2 11/13/2001	3 11/13/2001	Average
CO ppmvd @ 15% O ₂	39.7	39.3	39.1	39.3

Omega Hills, Wisconsin Landfill

Turbine No. 1.

Parameter	1 5/13/1986	2 5/13/1986	3 5/13/1986	Average
CO ppm	35.5	29.8	30.7	28.7

Metro, Wisconsin Landfill

Turbine No. 1.

Parameter	1 11/15/1988	2 11/15/1988	3 11/15/1988	Average
CO ppm	42	39.6	41	41

Altamont Electric Company, CA

Turbine No. 1.

Parameter	1 10/04/1994	2 10/04/1994	3 10/04/1994	Average
CO ppmvd @ 15% O ₂	42.96	42.66	46.30	43.9

Turbine No. 2.

Parameter	1 11/14/2001	2 11/14/2001	3 11/14/2001	Average
CO ppmvd @ 15% O ₂	43.62	43.97	43.10	43.56

In addition to the stack test results mentioned above, the Department also analyzed more than 60 test data for CO emissions from landfill gas-fired turbines located at various facilities operated by Waste Management. The CO emissions range from 14.71 to 81.71 ppmvd corrected at 15% oxygen.

BAT Determination

Based on the above stack test results summary, CO emissions from landfill gas-fired turbines range from 14.71 to 81.71 ppmvd corrected to 15% oxygen. Since CO emissions from landfill gas-fired turbine(s) are also dependent on fuel composition, and landfill gas compositions vary at different sites, a buffer should be added to the achievable CO emission level for all turbine types, landfill compositions, and operating modes. Therefore, a CO emission rate of 100 ppmvd corrected to 15% oxygen is considered as BAT for CO for landfill gas-fired turbine(s).

BAT for SO₂ Emissions

SO₂ Control

Fuel gas treatment for sulfur removal may remove approximately 80 percent of sulfur. However, because of higher costs, this technology has not been demonstrated in practice and therefore has been excluded from BAT analysis.

The Department has learned about the Desulfurization unit installed on six landfill gas-fired turbines operating at Central Sanitary Landfill & Recycling Center, Pompano Beach, FL. However, according to the technical memorandum by Florida DEP, the Desulfurization unit was installed to control odor problems. The FL DEP has established SO₂ limit of 150 ppm, 156.2 tons per year or 0.8 wt. % of sulfur content in landfill gas.

In order to determine the lowest feasible SO₂ emission rate without any additional control, the Department reviewed the following actual stack test results for various uncontrolled landfill gas-fired turbines:

Pottstown Landfill

Turbine No. 1.

Parameter	1 7/31/1989	2 7/31/1989	3 7/31/1989	Average
SO ₂ ppmvd @ 15% O ₂	4.0	2.3	3.3	3.2

Turbine No. 1.

Parameter	1 09/30/03	2 09/30/03	3 10/01/03	Average
SO ₂ ppmvd @ 15% O ₂	0.0	2.9	2.3	1.7

Turbine No. 2.

Parameter	1 7/31/1989	2 7/31/1989	3 7/31/1989	Average
SO ₂ ppmvd @ 15% O ₂	2.1	1.2	3.1	2.1

Turbine No. 2.

Parameter	1 09/30/03	2 09/30/03	3 10/01/03	Average
SO ₂ ppmvd @ 15% O ₂	1.2	2.6	1.5	1.8

GROWS Landfill

Turbine No. 1.

Parameter	1 7/25/1988	2 7/25/1988	3 7/25/1988	Average
SO ₂ ppmvd @ 15% O ₂	5.3	6.1	6.7	6.0

Green Knight Economic Development Corp.

Turbine No. 1.

Parameter	1 11/15/2001	2 11/15/2001	3 11/15/2001	Average
SO ₂ ppmvd @ 15% O ₂	25.6	25.3	26.9	25.9

Turbine No. 2.

Parameter	1 11/14/2001	2 11/14/2001	3 11/14/2001	Average
SO ₂ ppmvd @ 15% O ₂	19	18.3	18.9	18.7

BAT Determination

Based on the above stack test results summary, SO₂ emissions at 100% load range from 1.7 to ~26 ppmvd corrected to 15% oxygen. In addition, two turbines at Green Knight Economic Corp. have been permitted at 32 ppmvd corrected to 15%. Landfill gas turbines at this facility are able to achieve SO₂ emissions less than the allowable limit. Applying a buffer of approximately 20% to the maximum emitted SO₂ emission, 30 ppmvd SO₂ corrected to 15% oxygen is determined to be BAT for landfill gas-fired turbines. Also, as required by NSPS Subpart GG a sulfur content of 0.8 percent by weight will be considered BAT.

BAT for PM Emissions:

PM Control

Flue gas pretreatment for particulate removal has been achieved in practice and has been considered as BAT. EPA's AP-42 (Table 3.4-3) emission factors recommend 0.0232 lb/MMBtu (LHV) for landfill gas-fired turbines.

Stack test results for turbines at Green Knight Economic Development Corp. shows that both turbines were restricted to a PM₁₀ emission rate of less than 0.92 lbs/hr (equivalent to 0.01 lb/MMBtu) and both were able to achieve a PM₁₀ emission rate of less than 0.7 lbs/hr. In recently issued Plan Approval for landfill gas fired turbines, a PM limit was established at 2.5 lbs/hr.

The Department doesn't have a wide range of data for PM emissions from landfill gas-fired turbines. Therefore, the Department has determined the Particulate Matter (PM) limit of 0.0232 lb/Mmbtu as recommended in EPA's AP-42 document.

Performance Testing Requirements

Condition 9 of the General Permit describes various alternatives to show compliance with air pollution emissions rates for new turbines as well as a turbine that has had its “turbine core” replaced with identical components.

Monitoring, Recordkeeping, and Reporting Requirements

Conditions 10, 11 and 12 of the General Permit summarize monitoring, recordkeeping, and reporting requirements such as monitoring the monthly amount of landfill gas fired in each turbine, number of hours of operation per month, and keeping these records for a minimum of five years to present to the Department upon request.

PUBLIC NOTICE AND COMMENTS

In accordance with 25 Pa. Code §127.612, the Department published notice of the proposed General Permit in the Pennsylvania Bulletin (34 Pa. B. 5442) on March 26, 2005, and in six newspapers of general circulation to provide notice and an opportunity to comment. The notice was also sent to EPA and to Ohio, West Virginia, Virginia, Maryland, Delaware, New Jersey and New York. The initial comment period for receipt of public comments was for 45 days; however, the comment period was extended for the next few days to receive late comments.

STATUTORY AUTHORITY

After revising the General Permit based on the comments received above, it will be finalized and authorize construction, modification, or replacement of landfill gas-fired turbines under authorization of §6.1(f) and (g) of the Air Pollution Control Act, 35 P.S. § 4006.1, and 25 Pa. Code §§ 127.611 and 127.631.