San Joaquin Valley
Unified Air Pollution Control District

Best Available Control Technology (BACT) Guideline 1.9.3*

Emissions Unit: Crematory – Gaseous Fuel Fired
Industry Type: Funeral Service and Crematories, Animal Crematory

Equipment Rating: all **Last Update:** June 9, 2022

Pollutant	Achieved in Practice or contained in SIP	Technologically Feasible	Alternate Basic Equipment
NOx	Natural Gas/LPG fuel and 60 ppmv @ 3% O2 (0.073 lb/MMBtu) without charge		
SOx	Natural Gas/LPG fuel	Natural Gas/LPG fuel with a Dry Scrubber and a Baghouse	
VOC	Natural Gas/LPG fuel and a secondary combustion chamber (afterburner) ≥ 1600 º F		
PM10	Natural Gas/LPG fuel and a secondary combustion chamber (afterburner) ≥ 1600 º F	Natural Gas/LPG fuel with a Baghouse	

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

***This is a Summary Page for this Class of Source**

Proactive Best Available Control Technology Analysis

District BACT Guideline 1.9.3

Crematory – Natural Gas/Propane/LPG-Fired

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(Updated June 9, 2022)

I. Introduction

The objective of this project is to proactively update the Best Available Control Technology (BACT) guideline 1.9.3, which covers natural gas-fired crematories. This guideline was last updated on June 1, 2005. This BACT guideline covers all crematories (human remains and animals) in the San Joaquin Valley Unified Air Pollution Control District (the District). A survey of crematory operations in the District shows there are natural gas-fired and propane/LPG-fired operations. Propane/LPG is typically only used in areas where natural gas service is not available. Similar emissions are expected when the crematories are fired on natural gas, propane, or LPG. The specification of LPG includes propane. Therefore, updated BACT guideline 1.9.3 will include LPG as fuel.

This proactive update is necessary to incorporate the most stringent emission control standards that have been achieved in practice. Furthermore, the proactive update to this BACT guideline will bring consistency in implementing the BACT standard throughout the regional offices of the District for new and modified crematory operations triggering BACT. The discussion in this document will be limited to the following items:

- Source of emissions
- Top-Down BACT Analysis for each pollutant
- Recommendation

II. Source of emissions

This BACT determination applies the incineration of both animal and human remains.

The remains are placed in the primary chamber of the crematory incinerator where gas-fired burner(s) are utilized to incinerate the remains. The emissions from the incineration process are drawn into the secondary chamber where a secondary burner (afterburner) is utilized to control the emissions prior to being released into the atmosphere. The operation results in the emission of:

- Emissions from the combustion of a gaseous fuel
- PM and VOC emissions from the incineration of animal and human remains

<u>Emissions from combustion of gaseous fuel</u>:
Conventional burners thoroughly mix all the fuel and air in a single stage just prior to combustion. NOx, SOx, PM10, CO, and VOC may be emitted from the combustion of natural gas or LPG.

<u>Emissions from incineration of remains:</u>
The incineration of remains releases PM and VOC hazardous air pollutants such as Hexavalent Chromium and Toluene respectively. Nitrogen and sulfur content of the remains may be respectively oxidized to NOx and SOx.

This proactive BACT determination will address all pollutants emitted during the cremation process with the exception of CO. Emissions exceeding the BACT trigger threshhold for CO are not expected of any crematory operations within the scope of this guideline.

III. Top Down BACT Analysis for NOx, VOC, PM_{10} and SOx Emissions

As explained earlier, NOx, VOC, PM_{10}, and SOx will be emitted due to fuel combustion and the calcination of remains.

Step 1 – Identify All Possible Control Technologies

A. Survey of BACT Guidelines

The following published BACT Guidelines were reviewed to determine potential control technologies for this class and category of operation:

- The U.S. Environmental Protection Agency (USEPA) RACT/BACT/LAER Clearinghouse,
- California Air Resources Board (CARB) BACT Clearinghouse,
- South Coast Air Quality Management District (SCAQMD),
- Sacramento Metropolitan Air Quality Management District (SMAQMD),
- Bay Area Air Quality Management District (BAAQMD),
- San Diego County Air Pollution Control District (SDCAPCD), and
- San Joaquin Valley Air Pollution Control District (SJVAPCD)

The EPA RACT/BACT/LAER clearinghouse does not include general guidelines, only determinations made by individual agencies. There was no relevant data in the clearinghouse for crematory units.

The CARB BACT clearinghouse does not include general guidelines, only individual determinations made by individual air districts. The relevant data are summarized in the following Achieved in Practice BACT and Technologically Feasible BACT tables.

The SCAQMD, BAAQMD, SMAQMD, and SJVAPCD BACT clearinghouses include relevant guidelines. The SDCAPCD clearinghouse does not include any BACT requirements for crematory operations. Achieved in Practice, which is required of all subject operations, are summarized in the following Achieved in Practice and Technologically Feasible BACT tables.

Achieved in Practice (AIP) BACT					
Air District	**Guideline#: Source Category (revision date)**	**Criteria Pollutant**			
		NOx	**SOx**	**VOC**	**PM10**
SCAQMD	Crematory, Non-Major Source (10/20/2000)	Natural Gas	Natural Gas	Secondary Combustion Chamber, ≥1500 F	Secondary Combustion Chamber, >1500 F
BAAQMD	53.1: Crematory, All (9/12/2007)	Natural Gas	Natural Gas	Secondary Combustion Chamber, ≥1500 F	Secondary Combustion Chamber, ≥1500 F
SMAQMD	232: Crematory, Animal (8/11/2020)	60 ppm at 30% O2 or 0.073 lb/MMBtu	Natural Gas	Natural gas fired with secondary chamber operating at ≥ 1600 F	Natural gas fired with secondary chamber operating at ≥ 1600 F
SJVAPCD	1.9.3: Crematory Natural Gas Fired (6/1/2005)	natural gas fuel	natural gas fuel	Natural gas fuel and a secondary chamber (afterburner) operating at ≥ 1600 F	Natural gas fuel and a secondary chamber (afterburner) operating at ≥ 1600 F

Note: the requirements for emission factors (in ppm or lb/MMBtu) are specified when the incinerator is burning only natural gas or LPG fuel, not during normal operation when incinerating charge.

Technologically Feasible options from each BACT Guideline, which may be required pending project-specific cost-effectiveness evaluation, are summarized in the table below.

Technologically Feasible (TF) BACT						
Air District	**Guideline# / Source Category (revision date)**	**Criteria Pollutant**				
		NOx	**SOx**	**VOC**	**CO**	**PM10**
BAAQMD	53.1 Crematory, All (9/12/2007)	n/d	n/d	n/d	n/d	Secondary Combustion Chamber, ≥1600 F (set point at 1650 F)
SJVAPCD	1.9.3: Crematory Natural Gas Fired (6/1/2005)	1. 9 ppmv NOx @ 3% O2 (0.011 lb/MMBtu) SCR or equiv. 2. 20 ppmv NOx @ 3% O2 (0.024 lb/MMBtu) Low NOx burner	1. Natural gas with a dry scrubber and a baghouse 2. Natural gas fuel with a wet scrubber	n/d	n/d	1. Natural gas fuel with baghouse 2. Natural gas fuel with venturi scrubber

Note: "n/d" indicates no emission standard or control requirement has been determined.

Summary of BACT Guideline Requirements:

Based on the above information, the current BACT options for crematory operations would be:

i. NOx

- 9 ppmv NOx @ 3% O2 (0.011 lb/MMBtu) SCR or equiv. (TF)
- 20 ppmv NOx @ 3% O2 (0.024 lb/MMBtu) Low NOx burner (TF)
- 60 ppmv @ 3% O2 (0.073 lb/MMBtu) without charge (TF)
- Use of Natural Gas or LPG fuel (AIP)

ii. SOx

- Use of Natural Gas or LPG Fuel with a Dry Scrubber and a Baghouse (TF)
- Use of Natural Gas or LPG Fuel with a Wet Scrubber (TF)
- Use of Natural Gas or LPG Fuel (AIP)

iii. VOC

- Use of Natural gas or LPG fuel and a secondary combustion chamber (afterburner) ≥ 1600 F (AIP)

iv. PM10

- Use of Natural gas or LPG fuel with baghouse (TF)
- Use of Natural gas or LPG fuel with venturi scrubber (TF)
- Use of Natural gas or LPG fuel and a secondary combustion chamber (afterburner) ≥ 1600 F (AIP)

B. Survey of Permitted Sources

The SJVAPCD currently has 65 active PTOs for crematory incinerators. Human remains are processed in 45 of these; animal remains are processed in 20. Three units can be fired on Natural gas or LPG fuel, four units are fired exclusively on LPG, and the remaining units are fired exclusively on NG. The median total rated heat input is 2 MMBtu/hr; the highest and lowest are respectively 6.25 and 0.4 MMBtu/hr.

The SJVAPCD has not historically required source testing for this source type due to overall small quantity of emissions and complication of reliable source testing due to high exhaust temperature and variability during operation. Emission limits are most commonly specified on a basis of the weight of charge incinerated. The source of the emission factors is generally AP-42 or manufacturer's data. Survey of permitted emission factors on the basis of charge weight incinerated are summarized in the table below:

Permitted Emission Factor Summary (lb-pollutant/ton-charge)				
	NOx	**SOx**	**VOC**	**PM10**
max	19.6	10.6	4.8	11.2
median	3.56	2.18	0.3	2.4
min	2.4	0.04	0.04	0.7

One SJVAPCD ATC was identified (N-1706-2-0) that additionally incorporated a permit condition limiting NOx emissions "from the burners" to not exceed 60 ppm @3% O2 (0.073 lb/MMBtu). Source testing was not required of this permit unit.

Despite this range of permitted emission factors, the crematory incinerator equipment is nearly identical in design. Typical design includes a natural gas or LPG-fired primary chamber where the charge is incinerated, and a secondary combustion chamber with an afterburner also fired on natural gas or LPG, and no additional exhaust post-treatment controls.

C. Survey of District Rules

SJVAPCD Rules:

Rule 4301: Fuel Burning Equipment (12/17/1992)
This rule applies to fuel burning furnaces, boilers, apparatuses, stacks, and associated appurtenances that produce heat or power by indirect heat transfer. Crematory incinerators utilize direct heating – where the products of combustion come into direct contact with the material to be heated. Thus, crematory incinerators are not subject to Rule 4301.

Rule 4302: Incinerator Burning (12/16/1993)
This rule applies to any incineration activity or equipment. This rule requires multiple-chamber incinerators or equipment found to be equally effective at controlling pollution. Per District Practice the use of an afterburner operated at 1600 F satisfies this requirement.

Rule 4307: Boilers, Steam Generators, and Process Heaters – 2.0 MMBtu/hr to Less Than 5.0 MMBtu/hr (5/21/2016)
This rule applies to gaseous or liquid fueled boilers, steam generators, water heaters, or process heaters with total rated heat input in the range 2.0-5.0 MMBtu/hr. The definition of Process Heater excludes “kilns or ovens used for drying, baking, cooking, calcining, heat treating, or vitrifying.” Crematory incineration is considered calcination and therefore not subject to this rule.

Rule 4308: Boilers, Steam Generators, and Process Heaters – 0.075 MMBtu/hr to Less Than 2.0 MMBtu/hr (11/14/2013)
In the same manner as discussed above for Rule 4307, crematory incineration are not subject to Rule 4308.

Rule 4309: Dryers, Dehydrators, and Ovens
This rule applies to dryers, dehydrators, and ovens with total rated heat input greater than or equal to 5.0 MMBtu/hr. The crematory incineration process does not meet the definitions of source categories subject to this rule as the treatment of the biological material extends beyond “dried, dehydrated, or cured”. Thus, crematory incineration is not subject to Rule 4309.

Other Air District Rules:

SCAQMD Rule 1147: NOx Reductions from Miscellaneous Sources [1]
This SIP approved rule applies to many source types which combust gaseous or liquid fuel, including crematories. Emission limits are specified by equipment category. Crematory incinerators are included in the category "Burn-off Furnace, Burnout Oven, Incinerator or Crematory with or without Integrated Afterburner". This rule has required initial source testing demonstrating compliance prior to conversion to PTO. The applicable requirements is shown in the summary table below.

Summary of Applicable Rules and Regulations:

The requirements for these applicable rules and regulations are summarized in the table below:

Agency Rule/Regulation	Operating Parameters	NOx	PM10, VOC
SCAQMD Rule 1147	Process Temperature: ≤ 800 º F	60 ppm @ 3% O2 (0.073 lb/MMBtu)	N/A
	Process Temperature: > 800 º F and < º F 1,200	60 ppm @ 3% O2 (0.073 lb/MMBtu)	N/A
	Process Temperature: ≥ º F 1,200	60 ppm @ 3% O2 (0.073 lb/MMBtu)	N/A
SJVAPCD Rule 4302	Any incineration activity or equipment	There are no requirements for NOx emissions	Multi-Chamber Incinerator or equivalent

Note: The SCAQMD limits are specified when the incinerator is burning 100% fuel and not when incinerating.

[1] http://www.aqmd.gov/docs/default-source/rule-book/reg-xi/rule-1147.pdf

D. List of Control Options

Based on the survey of the above BACT determinations, rules and regulations, and District permitted operations, the following control options have been identified:

v. NOx

- 9 ppmv NOx @ 3% O2 (0.011 lb/MMBtu) SCR or equiv. (TF)
- 20 ppmv NOx @ 3% O2 (0.024 lb/MMBtu) Low NOx burner (TF)
- 60 ppmv @ 3% O2 (0.073 lb/MMBtu) without charge (AIP)
- Natural Gas (AIP)

The stipulation “without charge”, above, indicates this emission factor is required when the incinerator is burning 100% fuel and not when incinerating charge.

vi. SOx

- Use of Natural Gas or LPG Fuel with a Dry Scrubber and a Baghouse (TF)
- Use of Natural Gas or LPG Fuel with a Wet Scrubber (TF)
- Use of Natural Gas or LPG Fuel (AIP)

vii. VOC

- Use of Natural Gas or LPG Fuel and a secondary combustion chamber (afterburner) ≥ 1600 F (AIP)

viii. PM10

- Use of Natural Gas or LPG Fuel with baghouse (TF)
- Use of Natural Gas or LPG Fuel with venturi scrubber (TF)
- Use of Natural Gas or LPG Fuel and a secondary combustion chamber (afterburner) ≥ 1600 F (AIP)

Step 2 - Eliminate Technologically Infeasible Options

i. NOx

SJVAPCD BACT Guideline 1.9.3 (6/1/2005) lists 9 ppmv NOx @ 3% O2 (0.011 lb/MMBtu/hr) SCR or equivalent as technologically feasible. SCR is usually installed on units that run continuously, which keeps the exhaust at a temperature the catalyst requires. Crematory incinerators operate in a batch mode requiring cool down between charges to allow collection of residual remains. Further, the typical normal exhaust temperature of crematory incinerators is 1,600 °F, which exceeds the optimum operational range of SCR

(480 to 800 °F)[2]. Additionally, the SCR catalyst can be poisoned by contaminants that are contained in the exhaust, such as beryllium, cadmium, chromium, and mercury (per the SJVAPCD toxics profile for Crematory and Incinerator operations). Therefore, use of an SCR system to achieve a NOx emission limit of 9 ppmv @ 3% O2 (0.011 lb/MMBtu) SCR or Equivalent is deemed technologically infeasible and has been removed from consideration.

Furthermore, a 2022 survey conducted by GeoInsight, Inc on behalf of Ceres Memorial Park (N-1804, 1212965) found no burners were commercially available for this application that meet the 20 ppmv-NOx requirement. The survey included consultation with an international burner manufacturer, Facultatieve Technologies, who stated they could not produce a burner that could meet the operational requirements of a crematory incinerator application while simultaneously meeting the 20 ppmv-NOx requirement. Further, the survey included consultation with a company specializing in incinerator burners (Olstrad Engineering) who stated that, to their knowledge no crematory incinerator burner was available nationally or internationally that could meet a 20 ppmv-NOx requirement. Thus, the option of a low-NOx burner meeting a 20 ppmv-NOx requirement is deemed to be technologically infeasible to implement at this time; therefore, this option has been removed from consideration.

The remaining NOx control options are:

- 60 ppmv @ 3% O2 (0.073 lb/MMBtu) without charge (AIP)
- Use of Natural Gas or LPG Fuel (AIP)

ii. SOx

SJVAPCD BACT Guideline 1.9.3 currently lists a wet scrubber as technologically feasible in Step 1. Wet scrubbers control SOx by dispersing an aqueous slurry in the exhaust gas stream that absorbs and chemically reacts with SOx. The slurry droplets are removed by allowing them to settle on mist eliminator surfaces. The operational requirements of wet scrubbers requires the droplets remain liquid, thus this design is unsuitable for application to gas streams of elevated temperatures that would cause droplet evaporation. Typical applications of wet scrubbers for SOx control have inlet gas temperatures less than 700 °F[3]. The expected exhaust temperature of the proposed crematory incinerator is 1,600 °F. Thus, the option of a wet scrubber is deemed to be infeasible to implement at this time and, therefore, has been removed from consideration.

[2] US EPA. Air Pollution Control Technology Fact Sheet: SCR. EPA-452/F-03-032. https://www3.epa.gov/ttncatc1/dir1/fscr.pdf
[3] US EPA. Air Pollution Control Technology Fact Sheet: Flue Gas Desulfurization – Wet, Spray Dry, and Dry Scrubbers. EPA-452/F-03-034. https://www3.epa.gov/ttn/catc/cica/files/ffdg.pdf

The remaining SOx control options are:

- Use of Natural Gas or LPG Fuel with a Dry Scrubber and a Baghouse (TF)
- Use of Natural Gas or LPG Fuel (AIP)

iii. VOC

There are no technologically infeasible options listed in Step 1. All of the VOC emission control options under consideration are based on current BACT requirements, permitted operations, or common industrial technologies.

The VOC control options are:

- Use of Natural Gas or LPG Fuel ,and a secondary combustion chamber (afterburner) ≥ 1600 º F (AIP)

iv. PM10

SJVAPD BACT Guideline 1.9.3 lists a natural gas with a venturi scrubber as technologically feasible in Step 1. Per EPA Fact Sheet (EPA-452/F-03-017), venturi scrubbers can be used to reduce PM emissions for exhaust streams with temperature ranging from 40°F to 750°F[4]. Since the exhaust stream temperature (1600 °F) of of typical crematory incinerators falls outside the range of typical venturi scrubber application, the use of the technology is deemed infeasible for the proposed project. Therefore, this option has been removed from consideration.

The remaining PM10 control options are:

- Use of Natural Gas or LPG Fuel, with a Baghouse (TF)
- Use of Natural Gas or LPG Fuel, and a secondary combustion chamber (afterburner) ≥ 1600 º F (AIP)

[4] US EPA. Air Pollution Control Technology Fact Sheet: Venturi Scrubber. EPA-452/F-03-017. https://www3.epa.gov/ttn/catc/cica/files/fventuri.pdf

Step 3 - Rank Remaining Control Technologies by Control effectiveness

i. NOx

Rank	Control Efficiency or Emission Rate	Achieved in Practice
1	60 ppmv @ 3% O2 (0.073 lb/MMBtu) without charge	Yes
2	Natural Gas/Propane/LPG Fuel	Yes

The NOx concentration limit when burning only fuel is contained in the SIP approved SCAQMD Rule 1147 and has been been required of multiple permitted crematory incinerators. Therefore, this is level of control is considered to be achieved in practice.

ii. SOx

Rank	Control Efficiency or Emission Rate	Achieved in Practice
1	Natural Gas with a Dry Scrubber and a Baghouse	No
2	Natural Gas/Propane/LPG Fuel	Yes

An exhaustive search did not reveal crematory incinerators operating with a dry scrubber. Therefore, while this control technology is feasible, it is not considered to be achieved in practice.

iii. VOC

Rank	Control Efficiency or Emission Rate	Achieved in Practice
1	Natural Gas and a secondary combustion chamber (afterburner) $\geq$ 1600 ºF	Yes

iv. PM10

Rank	Control Efficiency or Emission Rate	Achieved in Practice
1	Natural Gas with a Baghouse	No
2	Natural Gas and a secondary combustion chamber (afterburner) $\geq$ 1600 ºF	Yes

An exhaustive search did not reveal crematory incinerators operating with a baghouse. Therefore, while this control technology is feasible, it is not considered to be achieved in practice.

Step 4 - Cost Effectiveness Analysis

This is a proactive determination that is not part of a permitting action. Therefore, a cost effective analysis is not necessary.

Step 5 - Select BACT

As discussed in Section I, above, allowance for LPG fuel is included as pipeline NG is not available in all areas of the SJVAPCD and LPG emissions are not expected to be substantially different.

i. NOx

The following NOx emission control standard has been determined to be achieved in practice. This established performance standard is recommended as the Achieved in Practice requirement.

- Natural Gas/LPG Fuel and 60 ppmv @ 3% O2 (0.073 lb/MMBtu) without charge

ii. SOx

The following SOx emission control standards has been determined to be achieved in practice. This established performance standard is recommended as the Achieved in Practice requirement.

- Natural Gas/LPG Fuel

The following NOx emission control standards has been determined to be Technologically Feasible.

- Natural Gas with a Dry Scrubber and a Baghouse

iii. VOC

The following CO emission control standard has been determined to be achieved in practice and is recommended as the Achieved in Practice Requirement.

- Natural Gas and a secondary combustion chamber (afterburner) $\geq$ 1600 º F (AIP)

iv. PM10

The following PM10 emission control standard has been determined to be achieved in practice and is recommended as the Achieved in Practice Requirement.

- Natural Gas and a secondary combustion chamber (afterburner) ≥ 1600 º F (AIP)

IV. Recommendation

Upon approval, adopt the proposed draft BACT guideline in Appendix A into the District's BACT Clearinghouse.

Appendices

Appendix A: Proposed BACT Guideline 1.9.3
Appendix B: BACT Guideline 1.9.3 (6/1/2005)

Appendix A
Proposed Draft BACT Guideline 1.9.3

San Joaquin Valley
Unified Air Pollution Control District

Best Available Control Technology (BACT) Guideline 1.9.3*

Emissions Unit: Crematory – Gaseous Fuel Fired
Industry Type: Funeral Service and Crematories, Animal Crematory

Equipment Rating: all **Last Update:** June 9, 2022

Pollutant	Achieved in Practice or contained in SIP	Technologically Feasible	Alternate Basic Equipment
NOx	Natural Gas/LPG fuel and 60 ppmv @ 3% O2 (0.073 lb/MMBtu) without charge		
SOx	Natural Gas/LPG fuel	Natural Gas/LPG fuel with a Dry Scrubber and a Baghouse	
VOC	Natural Gas/LPG fuel and a secondary combustion chamber (afterburner) ≥ 1600 º F		
PM10	Natural Gas/LPG fuel and a secondary combustion chamber (afterburner) ≥ 1600 º F	Natural Gas/LPG fuel with a Baghouse	

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

***This is a Summary Page for this Class of Source**

Appendix B
BACT Guideline 1.9.3 (6/1/2005)

Best Available Control Technology (BACT) Guideline 1.9.3
Last Update: 6/1/2005

Crematory - Natural Gas Fired

Pollutant	Achieved in Practice or in the SIP	Technologically Feasible	Alternate Basic Equipment
NOx	natural gas fuel	1. 9 ppmv NOx @ 3% O2 (0.011 lb/MMBtu) SCR or equiv. 2. 20 ppmv NOx @ 3% O2 (0.024 lb/MMBtu) Low NOx burner	
PM10	natural gas fuel and a secondary combustion chamber (afterburner) => 1600 degrees F	1. Natural gas fuel with baghouse 2. Natural gas fuel with venturi scrubber	
SOx	natural gas fuel	1. Natural gas with a dry scrubber and a baghouse 2. Natural gas fuel with a wet scrubber	
VOC	natural gas fuel and a secondary combustion chamber (afterburner) => 1600 degrees F		

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in s a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.