ACTIVE

CATEGORY Type: **CREMATORY**

BACT Category: 19,094 MMBtu/hr and a 421 ton per year

BACT Determination Number: 340	**BACT Determination Date:** **1/16/2024**

Equipment Information

Permit Number: N/A -- Generic BACT Determination

Equipment Description: CREMATORY

Unit Size/Rating/Capacity: Minor Source BACT

Equipment Location:

BACT Determination Information

District Contact: Jeff Quok Phone No.: (279) 207-1145 email: jquok@airquality.org

ROCs	**Standard:**	Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1,600 °F
	Technology Description:	
	Basis:	Achieved in Practice
NOx	**Standard:**	60 ppmv corrected to 3% O2 or 0.073 lb/MMBTU
	Technology Description:	Measured as emissions from fuel burning only, not with the charge.
	Basis:	Achieved in Practice
SOx	**Standard:**	Natural gas fired
	Technology Description:	
	Basis:	Achieved in Practice
PM10	**Standard:**	Natural gas-fired with secondary chamber operating at ≥ 1,600 °F
	Technology Description:	
	Basis:	Achieved in Practice
PM2.5	**Standard:**	No Standard
	Technology Description:	
	Basis:	
CO	**Standard:**	Not addressed
	Technology Description:	
	Basis:	
LEAD	**Standard:**	
	Technology Description:	
	Basis:	

Comments: T-BACT standards will be considered as meeting the BACT standards.

777 12th Street, Ste. 300

SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT

Sacramento, CA 95814

BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION

DETERMINATION NOS.:	340
DATE:	1/16/2024
ENGINEER:	Jeffrey Quok

Category/General Equip Description:	Crematory
Equipment Specific Description:	Crematory – Natural Gas
Equipment Size/Rating:	19,094 MMBtu/yr and a 421 ton per year charge limit
Previous BACT Det. No.:	317

This BACT determination will update BACT #317 for Crematories (Human and Pet). The BACT determination will only evaluate the use of natural gas fired combustion. BACT #317 is being updated to address the 30 ppm NOx at 3% O_2 standard that has been found to be unachieved in practice. After discussions with the crematory industry it was found that cremation units have been unable to meet the 30 ppm NOx standard and no crematorium manufacturer is able to guarantee 30 ppm NOx for their crematories.

This determination will also include Best Available Control Technology for Toxics (T-BACT) for the hazardous air pollutants (HAP) associated with the process.

From the Cremation Association of North America, “Flame-based cremation uses flame and heat to reduce the human remains to bone fragments or cremated remains. This is completed within a machine called a cremator.”

Pet crematories work in a similar fashion.

The BACT for CO will be addressed at a later date, when a project exceeds the threshold requiring limitations. It is not expected that this type of equipment will be large enough to trigger BACT requirements for CO, since the District CO BACT trigger level is 550 lbs/day.

BACT/T-BACT ANALYSIS

A. ACHIEVED IN PRACTICE (Rule 202, §205.1a):

The following control technologies are currently employed as BACT/T-BACT for crematories by the following agencies and air pollution control districts:

US EPA

BACT
Source: EPA RACT/BACT/LAER Clearinghouse

Pollutant	Crematory	
	Standard	Source
VOC	No standard	N/A
NOx	No standard	N/A
SOx	No standard	N/A
PM10	No standard	N/A
PM2.5	No standard	N/A
CO	No standard	N/A

No determinations were identified.

T-BACT
Source: EPA RACT/BACT/LAER Clearinghouse

No determinations were found.

RULE REQUIREMENTS:
None

California Air Resource Board (CARB)

BACT
Source: CARB BACT Clearinghouse
CARB BACT Guidelines Search

Pollutant	Crematory	
	Standard	Source
VOC	No standard	N/A

Pollutant	Crematory	
	Standard	Source
NOx	No standard	N/A
SOx	No standard	N/A
PM10	No standard	N/A
PM2.5	No standard	N/A
CO	No standard	N/A

No determinations were identified.

T-BACT
There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:
No Rules have been identified.

Sacramento Metropolitan AQMD

BACT
Source: SMAQMD BACT #317 (1/30/23)

SMAQMD BACT #317 For a Crematory with Operation Restrictions of 19,710 MMBTU/Hr and a 677 ton per year Charge Limit	
Pollutant	**Standard**
VOC	Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1,600 °F
NOx	30 ppmv corrected to 3% O_2 or 0.036 lb/MMBTU[(A)], measured as emissions from the fuel burning, not with the charge.
SOx	Natural gas fired
PM10	Natural gas-fired with secondary chamber operating at ≥ 1,600 °F
PM2.5	No Standard
CO	Not addressed

(A) After discussions with the crematory industry it has been found that the 30 ppmv NOx standard is not achieved in practice. The District was unable to identify any crematorium manufacturers that guarantee 30 ppmv NOx emissions corrected to 3% O_2 (See Attachment B – Yorke Engineering, LLC Letter).

T-BACT
T-BACT has been identified as meeting the BACT requirements.

RULE REQUIREMENTS:
Rule 419 - NOx from Miscellaneous Combustion Units (10-25-2018)

New crematories fired at greater than 1,200 °F that are rated at 2 MMBTU/hr or greater located at a major source or greater than or equal to 5 MMBTU/hr located at an area source, must meet a standard of 60 ppmv corrected to 3% O_2 for NOx and 400 ppmv corrected to 3% O_2 for CO.

South Coast AQMD

BACT
Source: SCAQMD BACT Guidelines for Non-Major Polluting Facilities, Pg 35

SCAQMD BACT Guidelines for Crematory Rev 1 Date: 2-1-2019	
Pollutant	**Standard**
VOC	Natural gas fired, Secondary Chamber ≥ 1,500 °F
NOx	60 ppm and compliance with Rule 1147 (2-1-2019)[(A)]
SOx	Natural gas
PM10	Natural gas, Secondary Chamber ≥ 1,500 °F
PM2.5	No Standard
CO	No Standard

(A) Rule 1147 was updated on 5/6/22 with a lower standard of 30 ppm.

T-BACT
There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:

Rule 1147 - NOx Reductions from Miscellaneous Sources (5/6/22)

New crematories cannot exceed 30 ppmv corrected to 3% O_2 or 0.036 lb/MMbtu when fired on gaseous fuel or 60 ppmv or 0.073 lb/MMBTU when fired on liquid fuel and when the temperatures are greater than or equal to 1,200 °F and, per table 2 of this rule. CO limit of 1,000 ppmv corrected to 3% O_2 for all fuels.

Requirements of Table 2 Rule 1147

Table 2 - NOx and CO emission limits	**NOx Emission Limit PPM @ 3% O_2, dry or Pounds/MMBTU heat input**	
	NOx Limit	**CO Limit**
Crematory - Gaseous Fuel Fired Equipment	30 ppmv or 0.036 lb/MMbtu	1,000 ppmv

Although SCAQMD has set a standard of 30 ppm NOx for crematories, after discussion with industry, the SMAQMD has decided that the 30 ppm NOx standard is not achieved in practice. Currently, no crematorium manufacturers guarantee 30 ppmv NOx emissions (See Attachment B – Yorke Engineering, LLC Letter).

Crematories in SCAQMD have been able to be permitted by using Section (d)(7)(A) of the Rule, which allows units to limit NOx emissions to less than one pound per day averaged over a calendar month in lieu of complying with the 30 ppmv NOx limit.

San Joaquin Valley APCD

BACT
Source: SJVAPCD BACT Guideline 1.9.3 (6/9/22)

SJVAPCD BACT Guideline 1.9.3	
Pollutant	**Standard**
VOC	Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1,600 °F
NOx	60 ppmv@ 3% O_2 (0.73 lb/MMBTU) without charge
SOx	Natural gas fuel
PM10	Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1,600 °F
PM2.5	No Standard
CO	No Standard

T-BACT
There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:

Rule 4302 Incinerator Burning (12/16/93)
The rule states that a person shall not burn in any incinerator within the District except in a multi-chamber incinerator as defined in Rule 1020 (Definitions). Section 3.27 of Rule 1020 defines a multi chamber incinerator as that used to dispose of combustible refuse by burning. Since human or pet remains are not considered refuse, this definition and thus Rule 4302 is not applicable to this source category.

San Diego County APCD

BACT
Source: NSR Requirements for BACT (June 2011)

SDCAPCD NSR Requirements for BACT	
Pollutant	**Standard**
VOC	No Standard
NOx	No Standard
SOx	No Standard
PM10	No Standard
PM2.5	No Standard
CO	No Standard

T-BACT
There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:
None.

Bay Area AQMD

BACT
Source: BAAQMD BACT Guideline Document # 53.1 (9.12.2007)

From BAAQMD BACT Guideline – Crematory (Revision 1 Date: 9/12/2007)	
Pollutant	**Standard**
VOC	Secondary Combustion ≥ 1,500 °F
NOx	Natural Gas Fired
SOx	Natural Gas Fired
PM10	Secondary Combustion ≥ 1,500 °F
PM2.5	No Standard
CO	Secondary Chamber ≥ 1,500 °F

T-BACT
There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:
None.

Summary of Achieved in Practice Control Technologies

The following control technologies have been identified and are ranked based on stringency:

SUMMARY OF ACHIEVED IN PRACTICE CONTROL TECHNOLOGIES	
Pollutant	**Standard**
VOC	1) Natural gas fired and a secondary combustion chamber (afterburner) ≥ 1,600 °F, when fired on natural gas [SMAQMD, SJVAPCD] 2) Natural gas fired and a secondary combustion chamber (afterburner) ≥ 1,500 °F, when fired in natural gas [SCAQMD, BAAQMD]
NOx	1) 60 ppmv corrected to 3% O_2 or 0.073 lb/MMBTU measurement of the fuel burned only [SMAQMD, SJVAPCD] 2) Natural gas fired [BAAQMD]
SOx	Natural gas fired [SMAQMD, SCAQMD, BAAQMD, SJVAPCD]
PM10	1) Natural gas fired with secondary chamber operating at ≥ 1,600 °F [SMAQMD, SJVAPCD] 2) Natural gas fired with secondary chamber operating at ≥ 1,500 °F [SCAQMD, BAAQMD]
PM2.5	No Standard
CO	1) 400 ppmv corrected to 3% O_2 if the unit is greater than or equal to 2 MMBTU/hr at a major source or greater than or equal to 5 MMBTU/hr at an area source. [SMAQMD] 2) Secondary chamber operating at ≥ 1,500 °F [BAAQMD] 3) 1,000 ppmv at 3% O_2 [SCAQMD]

CO
The 400 ppmv corrected to 3% O_2 CO requirement listed in the table above was taken from SMAQMD Rule 419. Since there are currently no crematory units that operate at a major source nor any rated at greater than 5 MMBTU/hr operating at area sources, this standard will not be considered achieved in practice for this application.

The following control technologies have been identified as the most stringent, achieved in practice control technologies:

BEST CONTROL TECHNOLOGIES ACHIEVED		
Pollutant	**Standard**	**Source**
VOC	Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1,600 °F (natural gas)	SMAQMD, SJVAPCD

BEST CONTROL TECHNOLOGIES ACHIEVED		
Pollutant	**Standard**	**Source**
NOx	60 ppmv correct to 3% O_2 or 0.073 lb/MMBTU (natural gas)	SMAQMD, SJVAPCD
SOx	Natural gas fired	SCAQMD, SMAQMD, BAAQMD, SJVAPCD
PM10	Natural gas fired with secondary chamber operating at ≥ 1,600 °F	SMAQMD, SJVAPCD, BAAQMD
PM2.5	No standard	
CO	Secondary chamber operating at ≥ 1,500 °F (natural gas) & 1,000 ppmv correct to 3% O_2 (natural gas)	BAAQMD, SCAQMD

B. TECHNOLOGICALLY FEASIBLE AND COST EFFECTIVE (Rule 202, §205.1.b.):

Technologically Feasible Alternatives:
Any alternative basic equipment, fuel, process, emission control device or technique, singly or in combination, determined to be technologically feasible by the Air Pollution Control Officer.

The table below shows the technologically feasible alternatives identified as capable of reducing emissions beyond the levels determined to be "Achieved in Practice" as per Rule 202, §205.1.a.

Pollutant	Technologically Feasible Alternatives
VOC	No other technologically feasible option identified
NOx	Selective Catalytic Reduction (SCR)
SOx	1. Wet Scrubber 2. Dry Scrubber
PM10	1. Baghouse 2. Wet Scrubber 3. Dry Scrubber 4. Venturi Scrubber
PM2.5	1. Baghouse 2. Wet Scrubber 3. Dry Scrubber 4. Venturi Scrubber
CO	No other technologically feasible option identified

Updated in 2005, the SJVAPCD lists the use of a baghouse with a dry scrubber or a wet scrubber as technologically feasible for the control of SOx, the use of a baghouse and venturi scrubber for the control of PM10 and the use of an SCR or a low NOx burner for the control of NOx. The control strategies appear to be carryovers from other natural gas combustion operations and do not appear to be fully evaluated for a crematory. The BAAQMD evaluated the same source category in 2007 and does not list a baghouse, venturi scrubber, the use of an SCR or a low NOx burner as technologically feasible options. No other district lists these options as technologically feasible either. Additionally, SMAQMD contacted SJVAPCD (Manuel Salinas, Air Quality Engineer, 559-230-5833) and verified that an SCR, low NOx burner, baghouse or scrubber has not been installed on any crematories to date. Irrespective of the discussion above that questions San Joaquin's intent for listing add on controls as being technologically feasible for a crematory application, the following analysis will assume that add on controls are technologically feasible and a cost effectiveness determination needs to be conducted to determine if add on controls are in fact considered cost effective.

Cost Effective Determination:

After identifying the technologically feasible control options, a cost analysis is performed to take into consideration economic impacts for all technologically feasible controls identified.

Maximum Cost per Ton of Air Pollutants Controlled

1. A control technology is considered to be cost-effective if the cost of controlling one ton of that air pollutant is less than the limits specified below:

Pollutant	Maximum Cost ($/ton) (Amended 9/5/23)
VOC	25,300
NO_X	35,300
PM10	11,400
SO_X	18,300
CO	300

Cost Effectiveness Analysis Summary

This BACT determination will perform a cost effectiveness analysis in accordance with the updated EPA OAQPS Air Pollution Control Cost Manual. The interest rate was based on the previous 6-month average interest rate on United States Treasury Securities (based on the life of the equipment) and addition of two percentage points and rounding up to the next higher integer rate.

NOx:

SCR System:

A cost effectiveness analysis was done to determine if an SCR system could be considered cost effective to control the NOx from a crematory and is calculated in Appendix A of this document. The crematory is estimated to have a burner that when fired with no body will emit NOx at less than 60 ppmv when fired on natural gas. To estimate the NOx emissions attributed to the burning of the charge, AP-42 Chapter 2.3 - Medical Waste Incineration Table 2.3-1(7/93) was used. This value for NOx is 3.56 lb of NOx per ton of charge. As a worst-case assumption, and consistent with the crematory permitting manual of the BAAQMD, the NOx emission factor that is used in this analysis will be the combined emission factor of 6.87 lbs of NOx/ton of charge which includes the emission factor of combustion added to the emission factor from burning of the charge. Calculations are based on a crematory rated at 5.1 MMBTU/hr with a burn rate of 225 lbs/hr.

With a burn rate of 225 lbs per hour and operation occurring 12 hours per day, 6 days per week, and 52 weeks per year; the total charge would be 421 tons per year. With an SCR NOx control efficiency of 90%, the NOx emissions from the crematory are calculated to be 0.15 tons per year (421 TPY*6.87 lb/ton * (1 - 0.9) / 2000 lb/ton = 0.15 tons/year).

The cost for an SCR system was estimated using EPA's Cost Control Manual, 6th Edition. The SCR sizing criteria for which the costs are based are primarily determined from the exhaust flow rate and temperature. The spreadsheet that was used determines the flow rate from the burner rating.

The total annualized cost for the SCR system is estimated to be $46,030. The total NOx controlled would be 1.3 tons/year at 60 ppmv (421 tpy * 6.87 lb/ton * 0.9/2000 lb/ton = 1.3 tpy NOx controlled). The analysis shows the cost effectiveness calculation to be $35,345 per ton of NOx reduced. Since the District's cost effectiveness threshold for NOx is $35,300 per ton, the addition of the SCR would not be considered cost effective.

Total Annualized Cost of SCR	Quantity of NOx Controlled (TPY)	Cost of SCR per ton removed	SMAQMD cost effective threshold for NOx	Cost effective
$46,030	1.3 @ 60 ppmv	$ 35,345 @ 60 ppmv of NOx	$35,300	No

At these updated cost effective numbers, the new add-on control thresholds would be 19,094 MMBtu/hr (based on 5.1 MMBtu/hr burner and 3,744 hrs/year of operation) and 421 tons/year charge limit.

PM:

Baghouse:
A screening cost effectiveness analysis was done to determine if a baghouse could be considered cost effective to control the particulate from a crematory. Based on source testing of a crematory unit (P/O 24785 North Sacramento Funeral home Inc. source test) only about 32% of the total particulate collected is filterable. However, this analysis will assume that the baghouse will collect 100% of the filterable emissions which would be approximately 0.152 tons/yr, based on 12 hrs/day, 6 days/week, and 52 weeks/yr. With the District's particulate cost effectiveness threshold of $11,400/ton, interest rate of 6% and an equipment life of 10 years, the capital cost for the control would have to be less than $14,055 to be considered cost effective.

Based on EPA's Cost Control Manual, 6th Edition, the capital cost of a baghouse needed to control the flow characteristics of a crematory is estimated to be approximately $21,499.74 (refer to Attachment A). Since the capital costs of a baghouse alone are higher than the capital costs needed to be considered cost effective, the baghouse will not be considered cost effective. The analysis above only considers the amortized capital costs of the control device and no other annualized costs (such as maintenance, energy, etc.) were included. Inclusion of these other annualized costs would only drive the cost effectiveness higher.

Therefore, the conclusion is that a baghouse used to control particulate matter for a crematory is not considered cost effective and as such will not be considered BACT. See Appendix A for cost analysis.

Total Annualized Cost of a Baghouse	Quantity of PM10 Controlled (TPY)	Cost of a Baghouse per ton Removed	SMAQMD cost effective Threshold for PM10	Cost Effective
$2,921.13	0.152	$19,218	$11,400	No

Venturi Scrubber:
A screening cost effective analysis was done for a venturi scrubber using the EPA Cost Control Manual, 6th Edition. Unlike the baghouse discussion above, the entire PM quantity (filterable and condensable) was used for cost effectiveness determination, as opposed to only the filterable fraction of PM for the baghouse. The lowest cost option was considered when making the determination of costs. A venturi scrubber system sized to control 3,337 cfm of exhaust gas is estimated to cost $82,572 (refer to Attachment A) which only takes into account the equipment costs. The cost effectiveness for this system would then be $78,809 per ton of PM controlled. Since the system costs are greater than the District's cost effectiveness criteria, a venturi scrubber is not considered cost effective.

Total Annualized Cost of Venturi Scrubber	Quantity of PM10 Controlled (TPY)	Cost of Venturi per ton removed	SMAQMD cost effective threshold for PM10	Cost effective
$11,219	0.152	$72,809	$11,400	No

SOx:

Wet Scrubber:
A cost effectiveness analysis was done for the control of SOx with the use of a wet scrubber. Based on the information presented in the EPA Cost Control Manual, 6th Edition, the cost of the capital equipment was selected by using the lowest surface area and subsequent cost information available in this section of the manual. For SOx, the District's cost effectiveness threshold is $18,300 per ton. The cost of the wet scrubber was estimated to have a total annual cost of $27,571 (refer to Attachment A) and control efficiency was assumed to be 100%. The cost of the electricity, or caustic was not considered. The total SOx emissions controlled is 0.46 tons/year. The cost per ton removed for this control was calculated to be $58,807.49 and therefore is not considered to be cost effective.

Total Annualized Cost of Wet Scrubber	Quantity of SOx Controlled (TPY)	Cost of wet scrubber per ton removed	SMAQMD cost effective threshold for SOx	Cost effective
$27,052	0.46	$59,936	$18,300	No

Dry Scrubber:
The EPA Cost Control Manual, 6th Edition does not have a chapter on dry scrubbers. A dry scrubber consists of a dry reactant or powder injection system and a baghouse. Costs for a dry scrubber are estimated using the equipment costs of a baghouse plus the annual operating costs of a wet scrubber. Since the reference manual does not have cost information

for the powder injection system, the cost of electricity, powder reactant and the powder injection system were not considered in this analysis. The total annualized costs are estimated to be $23,132 (refer to Attachment A). The cost per ton of SOx removed is calculated to be $50,286 and therefore is not considered to be cost effective.

Total Annualized Cost of Dry Scrubber	Quantity of SOx Controlled (TPY)	Cost of Dry Scrubber per ton Removed	SMAQMD Cost Effective Threshold for SOx	Cost Effective
$23,402	0.46	$50,874	$18,300	No

PM + SOx:

Per the SMAQMD *Procedures for Making Best Available Control Technology (BACT) and Best Available Control Technology for Toxic (T-BACT) Determinations for New and Modified Emission Units (10/15)*, when a control technology is expected to control multiple forms of criteria pollutants both shall be assessed for cost effectiveness. In the case of a wet scrubber, the control of SOx, and PM10 should be considered. Per the calculation method found in the document, and assuming that 100% of PM10 and SOx is removed by the wet scrubber:

$$\text{Max Cost} = \sum^{P} (\text{Emissions Reduced} * \text{Cost Effectiveness Value})$$

P = Each pollutant subject to BACT

Max Cost = (0.152 ton PM10/yr X $11,400/ton PM) + (0.46 ton SOx/yr X $18,300/ ton SOx)
= $10,150.80/ yr

Since the annualized costs of a wet scrubber or a dry scrubber with baghouse is $27,571 and/or $23,402, respectively and since either is greater than the Max Cost value calculated above the use of a wet scrubber or dry scrubber with baghouse is not considered cost effective.

APC Device	**Total Annualized Cost**	**Quantity of SOx & PM10 Controlled per Yr**	**Aggregate Max Cost Threshold for SOx & PM10**	**Cost Effective**
Wet Scrubber	$27,571	0.46 tons SOx 0.156 tons PM10	$10,150.80	No
Dry Scrubber with Baghouse	$23,402	0.46 tons SOx 0.156 tons PM10	$10,150.80	No

C. SELECTION OF BACT:

No technologically feasible control technologies were found to be cost effective and therefore not selected. BACT will be standards that have been achieved in practice.

BACT #340 for a crematory with operation restrictions of 19,094 MMBTU/hr and a 421 ton per year charge limit		
Pollutant	**Standard**	**Source**
VOC	Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1,600 °F	SMAQMD, SJVAPCD
NOx	60 ppmv corrected to 3% O_2 or 0.073 lb/MMBTU, measured as emissions from the fuel burning, not with the charge	SMAQMD, SJVACPD
SOx	Natural gas fired	SCAQMD, SMAQMD, BAAQMD, SJVAPCD
PM10	Natural gas-fired with secondary chamber operating at ≥ 1,600 °F	SMAQMD, SJVAPCD,
PM2.5	No Standard	
CO	Not addressed	

D. SELECTION OF T-BACT:

There are no Federal NSPSs, NESHAPs nor State ATCMs for this source category. None of the sources surveyed have any toxic T-BACT determinations published. The District contacted the SCAQMD, the BAAQMD, and the SJVAPCD to inquire about any T-BACT determinations that may not have been published for this source category. In all cases, the T-BACT determinations were essentially the crematory's operational parameters that have been required as BACT. Therefore, T-BACT standards will be considered as meeting the BACT standards identified above.

APPROVED BY: Brian F Krebs **DATE:** 01-16-2024

Attachment A

Crematory – Control Equipment Cost Analysis

SCR COST EFFECTIVENESS CALCULATION

EPA AIR POLLUTION CONTROL COST MANUAL, Sixth Edition, EPA/452/B-02-001, January 2002
Section 4.2 - NOx Post-Combustion, Chapter 2 - Selective Catalytic Reduction

Cost Effectiveness = $ 35,344.50 $/ton

Equipment

Crematory rating	5.1	mmBTU/hr
Crematory Operating hours	3744	hours
Crematory capacity factor	1	
SCR Operating Days	312	days
Total Capacity Factor	0.854794521	
Baseline Nox (225 lb/hr burn rate, 3.56 lb/ton of charge*, 1.8 MMBTU/hr)		
*Nox emission Rate from AP-42 Table 2.3-1 Medical waste incineration	2.23E-01	lb/mmBTU
SCR Nox (90% control)	2.23E-02	lb/mmBTU
Ammonia Slip	10	ppm
Ammonia Stochiometric Ratio	1.05	
Stored Ammonia Conc	29	%
Amonnia Storage days	90	days
Sulfur Content	0.005	%
Pressure drop for SCR Ductwork	3	inches W.G.
Pressure drop for each Catalyst Layer	1	inche W.G.
Temperature at SCR Inlet	1297.783333	degrees F
Cost year	1998	
Equipment Life	10	years
Annual interest Rate	6	%
Catalyst cost, Initial	240	$/ft2
Catalyst cost, replacement	290	$/ft2
Electrical Power cost	0.05	$/KWh
Ammonia Cost	0.101	$/lb
Catalyst Life	24000	hr
Catalyst Layers	2 full, 1 empty	

	Buffalo Cremation			Lifeplan Cremations			
	9/18/2008			1/1/2011			**AVE**
Temperature at SCR Inlet	1316	1241	1193	1336.8	1366.3	1333.6	**1297.783**
$q_{flue\ gas}$	3904.7	3445.7	3734	2954	2976	3010	**3337.4**

Crematory Calculations

Q_B	5.1	mmBTU/hr
$q_{flue\ gas}$	2877.807603	acfm
N_{NOx}	0.9	

SCR Reactor Calculations

$Vol_{Catalyst}$	115.71313	ft3
$A_{Catalyst}$	2.997716253	ft2
A_{SCR}	3.447373691	ft2
l=w=	1.856710449	ft
n_{layer}	12	
h_{layer}	4.216702322	
n_{total}	13	
h_{SCR}	154.8171302	ft

Reagent Calculations

$m_{reagent}$	0.441013522	lb/hr
m_{sol}	1.520736281	lb/hr
q_{sol}	0.203154074	gph
Tank Volume	438.8127989	gal

Cost Estimation

Direct Costs

DC	$	198,301.05

Indirect Costs

General Facilites	$	9,915.05
Engineering and home office fees	$	19,830.10
Process Contingency	$	9,915.05
Total Indirect Installation Costs	$	39,660.21
Project Contingency	$	35,694.19
Total Plant Cost	$	273,655.44
Preproduction Cost	$	5,473.11
Inventory Capital	$	331.76
Total Capital Investment	$	279,460.32

Direct Annual Costs

Maintenance Costs	$	4,191.90	per yr
Power		4.391233875	KW
Annual Electricity	$	1,644.08	per yr
Reagent Solution Cost	$	1,345.49	per yr

Catalyst Replacement

FWF		0.314109813	
Annual Catalyst Replacement	$	878.38	per yr

Total Variable Direct Cost	$	3,867.94	per yr
Total Direct Annual Cost	$	8,059.85	per yr
CRF		0.135867958	
Indirect Annual Cost	$	37,969.70	per yr
Total annual Cost	$	46,029.55	per yr
NOx Removed		1.30	tons per year
Cost of Nox controlled per ton removal	$	35,344.50	per ton

	3.56	NOX lb/ton(A)		225 lb/hr (B)
		(A) - Table 2.3-1 AP-42, 2.3 Medical Waste Incineration		(B) Burn rate of the crematory
	3.31	Nox lb/ton (C)	based on a 2.7 mmbtu/hr unit	
		(C) - Natural gas combustion at 60 ppm		
	6.87	Combined Nox lb/ton		
tons of charge based on 12 hrs a day 6 days a week 52 weeks a year and burn rate of crematory		lb of Nox based on 3.56 lb of Nox/ ton of charge	LB of Nox controlled based on 90%	
421 tons		1.45 tons	1.30 tons	

PM10 Baghouse Cost Effective Requirements

PM Cost effective Number	11400	$/ton	
			Total PM =
PM emission from Crematory 23% of PM is filterable	0.152	tons/yer	0.152 ton/year
Cost needed to be cost effective	$ 1,732.80	$	
CRF (6% interest and 10 year life)	0.13586796		
P (Cost of control need to be cost effective)	**$ 12,753.56**		

Particulate Matter Control (Bag House) Cost Analysis

Gas to cloth ratio for shaker or reverse air bag house	1.8	
A	9	
B	0.8	
L	0.1	
D (mass mean diameter of particle, 7 um guess)	7	
V	4.95892838	equation 1.11
acfm of system	3337	acfm
Bag Size	672.927646	ft^2
Cost of Bag house common housing design	$ 7,127.18	$
Cost of insulation	$ 2,541.63	$
Cost of BAG Nextel, bottom bag removal	$ 11,217.70	high Temp Bags
Bag house cages	$ 50.14	
cage cost	$ 12.23	$/cage
Total cage costs	$ 613.23	$
Purchased equipment costs	**$ 21,499.74**	$
Annualized Cost	$ 2,921.13	
Cost effectiveness	$ 19,217.93	$/Ton controlled

PM10 Venturi Cost Effecive Analysis

Total PM	0.152	Tons/year			
PM Cost effectiveness	11400	$/tons controlled			
CRF (6% interest and 10 year life)	0.135868				

From Table 2.8 Direct and Indirect Installation Costs for Venturi Scrubbers, EPA Control Cost Manual 6th edition, 1-02

Ventur Packaged Unit (A1)	$14,098.43	150*Q(sat)^0.56	3337	acfm	low energy cabon steel
Additional Equipement (A2)	$11,278.74	80% of Unit			
Purchase Equipment Cost, PEC	$29,945.06	1.18*(A1+A2)			
Direct Installation Costs, DC	$16,769.24	0.56*PEC			
Total Indirect Costs, IC	$10,480.77	0.35*PEC			
Total	$82,572.25				
Total Annualized Cost	$11,218.92				
Cost Effectiveness	$73,808.70	$/Ton Controlled			

Cost Effective Requirements SOx Wet Scrubber

SOx Cost effective Number	18300	$/ton	
SOx emissions	0.46	tons/yer	
CRF (6% interest and 10 year life)	0.135867958		

SOx Control (Packed Tower) Cost Analysis

				Figure 1.4 pg 1-27, Setion 5.2 Post Combstion Controls, Chapter 1 Wet Scrubbers for Acid Gas
Total Capital Investment				
Tower Cost	$ 7,935.00		69 ft^2	Equation 1.40 pg 1-24, Setion 5.2 Post Combstion Controls, Chapter 1 Wet Scrubbers for Acid Gas
Packing Costs	$ 207.00			
AUX Eq (fan & Pump)	$ 4,071.00	1/2 the tower costs Guess		
PEC	$ 14,411.34			
DC	$ 22,594.05			
IC	$ 4,274.55			
TCI	$ 41,279.94			
Direct Annual Costs				Table 1.4, pg 1-28, Setion 5.2 Post Combstion Controls, Chapter 1 Wet Scrubbers for Acid Gas
Operating Labor	$ 3,659.76	(.5 hr/shift) (1 shift/8 hrs)(3,744 hrs/yr)*$15.64		
Supervisor	$ 548.96	15% of operating Labor		
Solvent (water)	$ 690.00			
Caustic replacement				
Watewater disposal				
Maintenance Labor	$ 4,027.14	(.5 hr/shift) (1 shift/8 hrs)(3,744 hrs/yr)*$17.21		
Material	$ 4,027.14	100% of maintenance labor		
Electricity				
Indirect Annual costs				
Overhead	$ 7,357.80	60% of total labor and material costs		
Admin charges	$ 825.60			
Property Tax	$ 412.80			
Insurance	$ 412.80			
Total indirect annual costs	$ 21,962.00			
Total annual costs	$ 27,570.63			
TAC/Ton of Sox controlled	$ 59,936.14			

Cost Effective Requirements SOx Dry Scrubber

SOx Cost effective Number	18300	$/ton	
SOx emissions	0.46	tons/yer	0.46
CRF (6% interest and 10 year life)	0.135867958		

SOx Control (Bag House) Cost Analysis

Gas to cloth ratio for shaker or reverse air bag house	1.8	
A	9	
B	0.8	
L	0.1	
D (mass mean diameter of particle, 7 um guess)	7	
V	4.958928378	equation 1.11
acfm of system	3337	acfm
Bag Size	672.927646	ft^2
Cost of Bag house common housing design	7127.180728	$
Cost of insulation	2541.628651	$
Cost of BAG Nextel, bottom bag removal	11217.70386	high Temp Bags
Bag house cages	50.14363979	
cage cost	12.22944239	$/cage
Total cage costs	613.228754	$
Purchased equipment costs	**21499.74199**	$

DC		
Operating Labor	$ 3,659.76	(.5 hr/shift) (1 shift/8 hrs)(3,744 hrs/yr)*$15.64
Supervisor	$ 548.96	15% of operating Labor
Maintenance Labor	$ 4,027.14	(.5 hr/shift) (1 shift/8 hrs)(3,744 hrs/yr)*$17.21
Material	$ 4,027.14	100% of maintenance labor
Electricity		
IC		
Overhead	$ 7,357.80	60% of total labor and material
Admin charges	$ 429.99	
Property Tax	$ 215.00	
Insurance	$ 215.00	
Total annualized costs	$ 23,401.92	
TAC/tons controlled	$ 50,873.74	

Attachment B

Yorke Engineering, LLC Crematory Letter

Yorke
ENGINEERING, LLC
www.YorkeEngr.com

May 2, 2023

Mr. Jeffrey Quok
Air Quality Engineer
Sacramento Metropolitan Air Quality Management District
777 12th Avenue
Sacramento, CA 95814
Work: (279) 207-1145
E-mail: JQuok@airquality.org

Subject: BACT NO_X Requirement for Crematory

Dear Mr. Quok:

Thank you for the opportunity to provide a response to the Sacramento Metropolitan Air Quality Management District (SMAQMD) requirements for oxides of nitrogen (NO_X) emissions from crematories. Based on the conversation between Mike Burwell of American Crematory Equipment Co. and the SMAQMD, it was understood that the SMAQMD is establishing 30 ppm NO_X as Best Available Control Technology (BACT) for crematories solely based on the NO_X requirements in South Coast Air Quality Management District (SCAQMD) Rule 1147-NO_X Reductions from Miscellaneous Sources.

BACT REVIEW

Crematories emits combustion emissions, including NO_X. Yorke has reviewed the current BACT for crematories from various air districts, focusing on the most recent BACT for NO_X. The summary of NO_X BACT for crematories is included in Table 1.

Table 1: NO_X BACT for Crematories

Source	NO_X BACT Determination	Date of BACT Determination
SCAQMD	60 ppm	2/1/2019
San Joaquin Valley Air Pollution Control District	60 ppm @ 3% O2 (BACT Guideline 1.9.3)	6/9/2022
Bay Area Air Quality Management District	Natural Gas Firing	9/12/2007

The SCAQMD Rule 1147 was promulgated May 6, 2022, prior to the San Joaquin Valley Air Pollution Control District crematory BACT determination.

As shown above, the current BACT determinations for crematories, aside from the SMAQMD's BACT Determination No. 317, was updated on 1/30/23 based on Rule 1147. The BACT category cited for SMAQMD BACT Determination No. 317 is natural gas crematories with ≤ 19,710 MMBtu/hr and 677 tons of charge/year. As shown in the following section, the Rule 1147 30 ppm NO_X requirements are not applicable to all natural gas crematories with ≤ 19,710 MMBtu/hr and 677 tons of charge/year, as stated in SMAQMD BACT Determination No. 317.

In-use crematory units and crematory units that choose to demonstrate compliance with NO_X emissions of less than one pound per day averaged over a calendar month, which is equivalent to a fuel limit of 411 MMBtu/month, based on 60 ppm NO_X or 0.073 lb of NO_X/MMBtu, are not subject to the NO_X requirements in Table 2 of Rule 1147.

No cost effectiveness analysis was completed for SMAQMD BACT Determination No. 317, and no units are currently in operation and demonstrating compliance with the 30 ppm of NOx.

RULE 1147 APPLICABILITY

The 30 ppm NO_X requirements in Table 2 of Rule 1147 referred in the SMAQMD BACT assessment for crematories apply to an equipment category that includes burn-off furnace, burnout oven, incinerator, and crematory with or without integrated afterburner, not solely for crematories. In addition, the NO_X requirements specified in Table 2 of Rule 1147 are not applicable to in-use units, which are defined as units that were in operation at the current location prior to May 6, 2022, and/or units with a SCAQMD permit application deemed complete prior to May 6, 2022, but have not yet been installed.

Rule 1147 allows for units with NO_X emissions less than one pound per day averaged over a calendar month to demonstrate compliance via recordkeeping in lieu of meeting the NO_X requirements in Table 2 of Rule 1147. Therefore, if a unit has a fuel usage limit of 411 MMBtu/month, based on one pound of NO_X per day averaged over a calendar month and 60 ppm NO_X emissions rate or 0.073 lb of NO_X/MMBtu, the unit is not required to meet the NO_X requirements in Table 2 of Rule 1147, and may choose to meet the 60 ppm NO_X emissions requirements.

Assuming that a crematory unit is equipped with a combined rating of 1.95 MMBtu/hr from the primary and secondary burners, the operational limit to meet 1 lb/day and not have to meet the 30 ppm NO_X requirements in Table 2 of Rule 1147 is 211 hours/month, or 49 hours/week.

Pursuant to the staff report for the amendment to Rule 1147, the SCAQMD assessed the NO_X Rule 1147 requirements for crematories as a more generic source category, including burn-off furnace, burnout oven, incinerator, or crematory with or without integrated afterburner, which consists of a total 314 units. During the study, source test results from 69 units in the category were analyzed, with only 9 units showing NO_X emissions of less than 30 ppm NO_X. None of the source tests showed consistent compliance demonstration with 30 ppm NO_X over a period of time. In conclusion, 87% of the source test results demonstrate failure to meet 30 ppm NO_X. Out of the 13% that showed less than 30 ppm NO_X, none has demonstrated consistent compliance over a period of time, which means that continued compliance with the 30 ppm NO_X limit for this source category has not been verified. To date, no crematorium manufacturer is able to guarantee 30 ppm NO_X for their crematories.

RULE 1147 SUPPORTING DOCUMENTS

Based on the review of the provided source test results from the Rule 1147 rule making document, five of the source-tested units are American Crematory units (Inland Memorial, O'Connor Laguna Hills Mortuary and Only Cremations for Pet). The Inland Memorial source tests were performed in 2014 demonstrating an inability to meet 30 ppm NO_x at 3% oxygen (O2). The O'Connor Laguna Hill Mortuary source tests were performed in 2013 with source test results showing 30 ppm NO_x

at 3% O2. The Only Cremation for Pets source tests were performed in 2018 with source test results showing 24 ppm NO_x at 3% O2 for pet crematory. There were no source test results from O'Connor Laguna Hill Mortuary or Only Cremations for Pets demonstrating that the crematories were able to consistently meet 30 ppm NO_x at 3% O2. Since the O'Connor Laguna Hill Mortuary source test was showing one result at 30 ppm NO_x at 3% O2, without any margin of compliance with the 30 ppm NO_x requirements in Table 2 of Rule 1147, we recommend removing this source test from the tests that show less than 30 ppm NO_x. In conclusion, none of the non-pet crematories source tests demonstrated consistent, repeatable results at less than 30 ppm NO_x at 3% O2.

CONCLUSION

Based on the above discussions, any crematory that meets the Rule 1147 threshold of one lb/day is not subject to the 30 ppm NO_X requirements, just the 60 ppm requirement, which would require a monthly fuel limit of 411 MMBtu/month. Thus Rule 1147 does not mandate 30 ppm NO_X for all crematories, so should not be considered BACT. We respectfully request that the SMAQMD review and reconsider the adoption of 30 ppm NO_X at 3% O_2 as BACT for Crematory NO_X.

Should you have any questions or concerns, please contact me at (619) 375-9142.

Sincerely,

Julie Mitchell
Principal Air Quality Scientist
Yorke Engineering, LLC
JMitchell@YorkeEngr.com

cc: Mike Burwell, American Crematory Equipment Co., mike@americancrematory.com
Carla Prasetyo Jo, Yorke Engineering, LLC, cjo@yorkeengr.com

Enclosures:

1. Attachment 1 – Other District BACT Determinations
2. Attachment 2 – SCAQMD Rule 1147 American Crematory Source Tests