SMAQMD BACT CLEARINGHOUSE

CATEGORY Type: **INCINERATOR/CREMATORY**

BACT Category: MINOR SOURCE

BACT Determination Number: 232	**BACT Determination Date:** **8/11/2020**

Equipment Information

Permit Number: N/A -- Generic BACT Determination

Equipment Description: CREMATORY - ANIMAL

Unit Size/Rating/Capacity: 4.5 MMBtu/hr

Equipment Location:

EXPIRED

BACT Determination Information

District Contact: Felix Trujillo Phone No.: (916) 874 - 7357 email: ftrujillo@airquality.org

ROCs	**Standard:**	No Standard
	Technology Description:	Natural gas fired and secondary combustion chamber (afterburner)=> 1600 F
	Basis:	Achieved in Practice
NOx	**Standard:**	60 ppm at 30% O2 or 0.073 lb/MMBtu
	Technology Description:	
	Basis:	Achieved in Practice
SOx	**Standard:**	No Standard
	Technology Description:	Natural gas fired
	Basis:	Achieved in Practice
PM10	**Standard:**	No Standard
	Technology Description:	Natural gas fired with secondary chamber operating at => 1600 F
	Basis:	Achieved in Practice
PM2.5	**Standard:**	No Standard
	Technology Description:	Natural gas fired with secondary chamber operating at => 1600 F
	Basis:	Achieved in Practice
CO	**Standard:**	No Standard
	Technology Description:	Secondary chamber => 1500 F
	Basis:	Achieved in Practice
LEAD	**Standard:**	
	Technology Description:	
	Basis:	

Comments: NOx standard is based on emissions from natural gas combustion only (not with the charge). BACT was based on a total burner rating of 4.5 MMBtu/hr operating at 4,380 hours/year (19,710 MMBtu/year) for natural gas combustion and a charge rate of 677 ton/year for the combustion of the animals. TBACT was determined to be equivalent to BACT.

Printed: 8/11/2020

777 12th Street, Third Floor

SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT

Sacramento, CA 95814

BEST AVAILABLE CONTROL TECHNOLOGY & TOXIC BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION

EXPIRED

DETERMINATION NO.:	232
DATE:	August 11, 2020
ENGINEER:	Felix Trujillo, Jr.

Category/General Equip Description:	Pet Crematory
Equipment Specific Description:	Pet Crematory
Equipment Size/Rating:	Minor Source BACT;4.5 MMBtu/hr Burners @ 4,380 hours/year of operation (19,710 MMBtu/year) and ≤ 677 Tons Charge/year
Previous BACT Det. No.:	145

This new pet crematory BACT will update the previous pet crematory BACT No. 145. The previous BACT was based on a 400 lb/hr crematory with a combined burner rating of 4.5 MMBtu/hr (A/C 25091). Since the time of this last permitting action, this size of crematory has been the largest received for any new applications. Therefore, this BACT will be based on this size of crematory.

BACT ANALYSIS

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

The following control technologies are currently employed as BACT for crematories.

US EPA

BACT
Source: EPA/ RACT/BACT/LEAR Clearinghouse

Crematory	
VOC	No Standard
NOx	No Standard
SOx	No Standard
PM10	No Standard
PM2.5	No Standard
CO	No Standard

Rule Requirements
None

CARB

BACT
Source: ARB BACT Clearinghouse

Crematory	
VOC	No Standard
NOx	No Standard
SOx	No Standard
PM10	No Standard
PM2.5	No Standard
CO	No Standard

Rule Requirements
None

SMAQMD

BACT

SMAQMD BACT #145 (1/13/17)	
VOC	No Standard, Natural gas-fired with secondary chamber operating at ≥1600 °F.
NOx	60 ppm @ 3% O2 or 0.073 lb/MMBtu
SOx	No Standard, Natural Gas Fired
PM10	No Standard, Natural gas-fired with secondary chamber operating at ≥1600 °F
PM2.5	No Standard
CO	No Standard, Secondary Chamber ≥ 1500 °F

Rule Requirements

Rule 419 - NOx from Miscellaneous Combustion Units (10/25/18)

New Crematories 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% O2 for NOx and 400 ppmv corrected to 3% O2 for CO.

South Coast AQMD

BACT

From SCAQMD BACT Guidelines for Non Major Polluting Facilities, Page 38	
VOC	No Standard, Natural Gas, Secondary Chamber ≥ 1500 °F
NOx	60 ppm Compliance with Rule 1147
SOx	No Standard, Natural Gas
PM10	No Standard, Natural Gas, Secondary Chamber ≥ 1500 °F
PM2.5	No Standard
CO	No Standard

Rule Requirements

Regulation XI, Rule 1147 - NOx Reductions from Miscellaneous Sources (7/7/17)

The purpose of this rule is to reduce nitrogen oxide emissions from gaseous and liquid fuel fired combustion equipment as defined in the rule. The rule requires that on or after January 1, 2010 any person owning or operating a unit subject to the rule shall not operate the unit in a manner that exceeds the applicable nitrogen oxide emission limits specified in table 1 at the time a District permit is required for operation of a new, relocated or modified unit. New, modified or relocated crematories fired at any temperature cannot exceed 60 ppm at 3% O_2 or 0.073 lb/MMBtu, Per Table 1 of this rule. A phone call to SCAQMD (Derek Hollinshead, 909-396-2275), permitting department confirmed that the NOx standard is for the burner operation only and not the cremation process (from BACT determination #133 – Human Crematory).

Requirements Table Rule 1147

Table 1 – NOx Emission Limit for Unit Heat Ratings 325,000 Btu/hour	**NOx Emission Limit** PPM @ 3% O2, dry or Pound/mmBtu heat input		
	Process Temperature		
Gaseous Fuel-Fired Equipment	≤ 800° F	> 800 ° F and < 1200° F	≥ 1200 ° F
Crematory	60 ppm or 0.073 lb/mmBtu	60 ppm or 0.073 lb/mmBtu	60 ppm or 0.073 lb/mmBtu

San Diego County APCD

BACT

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

Rule Requirements

None

Bay Area AQMD

BACT

From BAAQMD BACT Guideline (Document 53.1) – Crematory (9/12/07)	
VOC	No Standard, Secondary Combustion ≥ 1500 ^oF
NOx	No Standard, Natural Gas Fired
SOx	No Standard, Natural Gas Fired
PM10	No Standard, Secondary Combustion ≥ 1600 ^oF (set Point at 1650 ^oF)
PM2.5	No Standard
CO	No Standard, Secondary Chamber ≥ 1500 ^oF

Rule Requirements
None

San Joaquin Valley APCD

BACT

From SJVAPCD BACT Guidelines (1.9.3) – Crematory – Natural Gas Fired (6/1/05)	
VOC	No Standard, Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1600 ^oF
NOx	No Standard, Natural Gas Fuel
SOx	No Standard, Natural Gas Fuel
PM10	No Standard, Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1600 ^oF
PM2.5	No Standard
CO	No Standard

Rule Requirements
None

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

SUMMARY OF ACHIEVED IN PRACTICE CONTROL TECHNOLOGIES	
VOC	No Standard 1) Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1,600 ^{o}F, SMAQMD, SJVUAPCD 2) Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1,500 ^{o}F, SMAQMD, BAAQMD
NOx	60 ppm at 3% O2 or 0.073 lb/MMBTU measurement of the fuel burned only, SCAQMD, SMAQMD
SOx	No Standard, Natural Gas Fuel.
PM10	No Standard, 1) Natural gas-fired with secondary chamber operating at ≥1,600 ^{o}F SMAQMD, SJVAPCD, BAAQMD 2) Natural Gas, Secondary Chamber ≥ 1,500 ^{o}F, SCAQMD
PM2.5	No Standard
CO	No Standard, Secondary Chamber ≥ 1,500 ^{o}F, BAAQMD

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

BEST CONTROL TECHNOLOGIES ACHIEVED		
Pollutant	**Standard**	**Source**
VOC	No Standard, Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1,600 ^{o}F	SMAQMD, SJVUAPCD
NOx	60 ppm at 3% O2 or 0.073 lb/MMBTU	SCAQMD, SMAQMD
SOx	No Standard, Natural Gas Fired	SCAQMD, SMAQMD, BAAQMD, SJVAPCD
PM10	No Standard, Natural gas-fired with secondary chamber operating at ≥1600 ^{o}F	SMAQMD, SJVAPCD, BAAQMD
PM2.5	No Standard	
CO	No Standard, Secondary Chamber ≥ 1,500 ^{o}F	BAAQMD

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 and cost effective by the Air Pollution Control Officer.

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 venturi scrubber for the control of PM10 and the use of selective catalytic reduction (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 do 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, 559-230-5833) and verified that a 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. The driving factor for this BACT determination is the multi-pollutant cost effectiveness thresholds for SOx and PM10 calculated below. The limiting factor was based on yearly cremation of 677 tons/year and assuming the 4.5 MMBtu/hr burners operate 12 hours/day and 365 days/year. The life of the equipment was based on the life recommended in the cost manual. The interest was based on the previous 6-month average interest rate on US Treasury Securities + 2 points and rounding up to the next integer rate. As of June 5, 2020, the 10 year treasure rate (as found on http://www.multpl.com/10-year-treasury-rate/table/by-month) for the last 6 months beginning in January 1, 2020 and ending in June 1, 2020 was 1.76%, 1.50%, 0.87%, 0.66%, 0.67, and 0.82%. The average is 1.04%. Two percentage points are then added to the average interest rate and the interest rate is then rounded up to the next higher integer rate. Therefore, the resultant annual interest rate to be used is 1.04% + 2% = 4%.

The labor costs were based on data from the Bureau of Labor Statistics (operating labor: Occupation Code 49-9099, maintenance labor: Occupation Code 51-9051).

NOx:
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 only on natural gas with no body will emit NOx at less than 60 PPM. To estimate the NOx emissions attributed to the burning of the charge, AP-42 Chapter 2.3 - Medical Waste Incineration Table 2.3-1 was used. This value for NOx is 3.56 lb of NOx per ton of charge. The NOx emissions from natural gas combustion were based on the total burner rating of 4.5 MMBtu/hr and an operation time of 12 hours/day and 365 days/year. 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 5.68 lb of NOx/ton of charge which includes the emission factor of natural gas combustion added to the emission factor from burning of the charge.

The total charge would be 677 tons per year. With an SCR NOx control efficiency of 90%, the NOx emissions from the crematory is calculated to be 0.19 tons per year (677*5.68*(1-0.9)/2000=0.19).

A cost for a 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. However, a crematory unit's flow rate is much larger than the flow rate estimated from the burner rating alone as it is dependent on exhaust generated from natural gas combustion, exhaust generated from the charge itself, and additional excess air. As a result, the analysis will utilize the actual average flow rate observed during source testing of an identical crematory unit (see Attachment B) and a calculated equivalent burner rating.

The total annualized cost for the SCR system is estimated to be $42,749.47. The total NOx controlled would be 1.73 tons per year (677*5.68*0.9/2000 = 1.73). The analysis shows the cost effectiveness calculation to be $24,749.47 per ton of NOx reduced. Since the District's cost effectiveness threshold for NOx is $24,500 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
$42,822.85	1.73	$24,749.47	$24,500	No

PM:
A screening cost effectiveness analysis was done to determine if a baghouse could be considered cost effective to control the particulate from a crematory. This analysis will assume that the baghouse will collect 100% of the particulate emissions which would be approximately 1.65 tons/yr.

Based on EPA's Cost Control Manual, 6th Edition, the total annual cost of a baghouse needed to control the flow characteristics of a crematory is estimated to be approximately $30,155.76. The total PM10 emissions controlled would be 1.65 tons/year. The analysis shows the cost effectiveness calculation to be $18,276.22 per tons of PM10 reduced. 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
$30,155.76	1.65	$18,276.22	$11,400	No

A screening cost effective analysis was done for a venturi scrubber using the EPA Cost Control Manual, 6th Edition. The entire PM quantity (filterable and condensable) was used for cost effectiveness determination. A venturi scrubber system sized to control 3,341 cfm of exhaust gas is estimated to cost $55,050.82. The total annual cost is $32,665.40. The total PM10 emissions controlled would be 1.65 tons/year. The analysis shows the cost effectiveness calculation to be $19,630.65 per tons of PM10 reduced. 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
$32,665.40	1.664	$19,797.21	$11,400	No

SOx:

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 $32,464.21 and control efficiency was assumed to be 100%. The cost of the electricity was included. The cost of caustic was not considered. The total SOx emissions controlled is 0.74 tons/year. The cost per ton removed for this control was calculated to be $43,870.55 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
$32,464.21	0.74	$43,870.55	$18,300	No

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. Since the reference manual does not have cost information for the powder injection system, powder storage silo and powder reactant. The cost of the blower fan for the injection system was assumed to be 1/3 the size of the fan of a wet scrubber in order to determine the annual costs of the electricity for this system. The cost of the storage silo and powder reactant were not included. The total annualized costs are estimated to be $32,448.61. The cost per ton of SOx removed is calculated to be $43,849.47 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
$32,448.61	0.74	$43,849.47	$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 = (1.65 ton PM10/yr X $11,400/ton PM) + (0.74 ton SOx/yr X $18,300/ ton SOx)
= $32,352/yr

Since the annualized costs of a wet scrubber is $32,464.21 or a dry scrubber with baghouse is $32,448.61, 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 (TPY)	Aggregate Max Cost Threshold for SOx & PM10	Cost effective
Wet Scrubber	$32,464.21	0.745 tons SOx 1.664 tons PM10	$32,352	No
Dry Scrubber with Baghouse	$32,448.61	0.745 tons SOx 1.664 tons PM10	$32,352	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 For A Pet Crematory: 4.5 MMBtu/hr Burners @ 4,380 hours/year of operation (19,710 MMBtu/year) and ≤ 677 Tons Charge/year		
Pollutant	**Standard**	**Source**
VOC	No Standard, Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1,600 °F	SMAQMD, SJVUAPCD
NOx	60 ppm at 3% O2 or 0.073 lb/MMBTU, measured as emissions from the fuel burning, not with the charge	SCAQMD
SOx	No Standard, Natural Gas Fired	SCAQMD, SMAQMD, BAAQMD, SJVAPCD
PM10	No Standard, Natural gas-fired with secondary chamber operating at ≥ 1,600 °F	SMAQMD, SJVAPCD, BAAQMD
PM2.5	No Standard, Natural gas-fired with secondary chamber operating at ≥ 1,600 °F	SMAQMD, SJVAPCD, BAAQMD
CO	No Standard, Secondary Chamber ≥ 1,500 °F	BAAQMD

D. SELECTION OF T-BACT:

There are no Federal NSPS's, NESHAP's nor State ATCM's 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 enquire 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:** 08/11/2020

Appendix A 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 = $ 24,749.47 $/ton

Equipment

Crematory rating	4.952057895	mmBTU/hr					
Crematory Operating hours	4380	hours					
Crematory capacity factor	1						
SCR Operating Days	365	days					
Total Capacity Factor	1						
Baseline Nox (400 lb/hr burn rate, 3.56 lb/ton of charge*, 4.5 MMBTU/hr)							
*Nox emission Rate from AP-42 Table 2.3-1 Medical waste incineration	1.58E-01	lb/mmBTU					
SCR Nox (90% control)	1.58E-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.	Rolling Acres Test Results				
Pressure drop for each Catalyst Layer	1	inche W.G.	3/20/2013				**AVE**
Temperature at SCR Inlet	1641.67	degrees F		1475	1675	1775	**1641.67**
Cost year	1998						
Equipment Life	20	years					
Annual interest Rate	4	%					
Catalyst cost, Initial	240	$/ft2					
Catalyst cost, replacement	290	$/ft2					
Electrical Power cost	0.1124	$/KWh					
Ammonia Cost	0.101	$/lb					
Catalyst Life	24000	hr					
Catalyst Layers	2 full, 1 empty						

Crematory Calculations

Q_B	4.952057895	mmBTU/hr				
$q_{flue\ gas}$	3341	acfm	3013	3736	3274	**3341**
N_{NOx}	0.9					

SCR Reactor Calculations

$Vol_{Catalyst}$	262.0873365	ft3
$A_{Catalyst}$	3.480208333	ft2
A_{SCR}	4.002239583	ft2
l=w=	2.000559817	ft
n_{layer}	24	
h_{layer}	4.137831026	
n_{total}	25	
h_{SCR}	287.4457757	ft

Reagent Calculations

$m_{reagent}$	0.304084661	lb/hr
m_{sol}	1.048567798	lb/hr
q_{sol}	0.140077423	gph
Tank Volume	302.5672341	gal

Cost Estimation

Direct Costs

DC	$	269,633.34

Indirect Costs

General Facilites	$	13,481.67
Engineering and home office fees	$	26,963.33
Process Contingency	$	13,481.67
Total Indirect Installation Costs	$	53,926.67
Project Contingency	$	48,534.00
Total Plant Cost	$	372,094.00
Preproduction Cost	$	7,441.88
Inventory Capital	$	228.76
Total Capital Investment	$	379,764.64

Direct Annual Costs

Maintenance Costs	$	5,696.47	per yr
Power		7.353464282	KW
Annual Electricity	$	7,240.40	per yr
Reagent Solution Cost	$	927.73	per yr

Catalyst Replacement

FWF		0.320348539	
Annual Catalyst Replacement	$	1,014.51	per yr

Total Variable Direct Cost	$	9,182.64	per yr
Total Direct Annual Cost	$	14,879.11	per yr
CRF		0.07358175	
Indirect Annual Cost	$	27,943.75	per yr
Total annual Cost	$	42,822.85	per yr
NOx Removed		1.73	tons per year
Cost of NOx controlled per ton removal	$	24,749.47	per ton

	3.56	NOx lb/ton(A) (A) - Table 2.3-1 AP-42, 2.3 Medical Waste Incineration	400 lb/hr (B) (B) Burn rate of the crematory
	2.12	NOx lb/ton (C) (C) - Natural gas combustion at 60 ppm	
	5.68	Combined NOx lb/ton	
tons of charge based on yearly limitation to remain below the cost effectiveness threshold for NOx.		lb of NOx based on 3.56 lb of NOx/ ton of charge	LB of NOx controlled based on 90%
677 tons		1.92 tons	1.73 tons

PM10 Baghouse Cost Effective Requirements

PM Cost effective Number	11400	$/ton
PM emission from Crematory	1.65	tons/yer
CRF (4% interest and 20 year life)	0.07358175	

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	4.958928378	equation 1.11
acfm of system	3341	acfm
Bag Size	673.7342719	ft^2
Cost of Bag house common housing design	$ 7,132.96	$
Cost of insulation	$ 2,543.43	$
Cost of BAG Nextel, bottom bag removal	$ 11,231.15	high Temp Bags
Bag house cages	50.20	
cage cost	12.23	$/cage
Total cage costs	$ 613.96	$
Equipment Costs (A)	$ 21,521.50	
Instrumentation	$ -	0*A
California Sales taxes	$ 1,829.33	0.085*A
Freight	$ 1,076.08	0.05*A
Purchase Equipment Cost (**PEC**)	$ 24,426.90	
Direct & Indirect Installation Costs (DC & IC)	$ 4,885.38	0.2*PEC
Total Capital Investment (TCI)	$29,312.28	
Direct Annual Costs		
Operating Labor	$4,073.40	(.5 hr/shift) (1 shift/8 hrs)(4380 hrs/yr)*$14.88
Supervisor	$611.01	15% of operating Labor
Maintenance Labor	$4,864.54	(.5 hr/shift) (1 shift/8 hrs)(4380 hrs/yr)*$17.77
Material	$4,864.54	100% of maintenance labor
Electricity	$3,764.83	(0.000181)(3341 acfm)(10.3 in H2O)(4380 hr/yr)($0.138 kW/h)
Total Annual DC	$ 18,178.32	
Indirect Annual Costs		
Overhead	$8,648.09	60% of total labor and material
Admin charges	$586.25	2% of TCI
Property Tax	$293.12	1% of TCI
Insurance	$293.12	1% of TCI
Capital Recovery	$2,156.85	
Total Annual IC	$11,977.43	
Total Annal Costs (DAC + DIC)	$30,155.76	
TAC/tons controlled	**$18,276.22**	

PM10 Venturi Cost Effecive Analysis

Total PM	1.65	Tons/year			
PM Cost effectiveness	11400	$/tons controlled			
CRF (4% interest and 15 year life)	0.0899411				

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

Ventur Packaged Unit (A1)	$14,107.89	150*Q(sat)^0.56	3341	acfm	low energy cabon
Additional Equipement (A2)	$11,286.31	80% of Unit			
Equipment Costs (A)	$25,394.20	A=A1 + A2			
Instrumentation (assumed to be included per Section 6, Ch. 2, Table 2.5)	$0.00	0*A			
California Sales taxes	$2,158.51	0.085*A			
Freight	$1,269.71	0.05*A			
Purchase Equipment Cost (**PEC**)	$28,822.42				
Direct Installation Costs, DC	$16,140.56	0.56*PEC			
Total Indirect Costs, IC	$10,087.85	0.35*PEC			
Total Capital Investment (**TCI**)	$55,050.82				
Direct Annual Costs:					
Operating Labor	$4,073.40	(.5 hr/shift) (1 shift/8 hrs)(4380 hrs/yr)*$14.88			
Supervisor	$611.01	15% of operating Labor			
Electricity	$6,310.23	(0.7457)(13 hp + 1 hp)(4380 hr/yr)($0.138 kW/h)			
Maintenance Labor	$4,864.54	(.5 hr/shift) (1 shift/8 hrs)(4380 hrs/yr)*$17.77			
Material	$4,864.54	100% of maintenance labor			
Total Annual DC	$20,723.72				
Indirect Annual Costs:					
Overhead	$5,837.45	60% of total labor and material			
Admin charges	$576.45	2% of TCI			
Property Tax	$288.22	1% of TCI			
Insurance	$288.22	1% of TCI			
Capital Recovery	$4,951.33				
Total IAC	$11,941.68				
Total Annual Costs (DAC +IAC)	$32,665.40				
Cost Effectiveness	**$19,797.21**	$/Ton Controlled			

Cost Effective Requirements SOx Dry Scrubber

SOx Cost effective Number	18300	$/ton
SOx emissions	0.74	tons/yer
CRF (4% interest and 15 year life)	0.0899411	

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	3341	acfm
Bag Size	673.7342719	ft^2
Cost of Bag house common housing design	$7,132.96	$
Cost of insulation	$2,543.43	$
Cost of BAG Nextel, bottom bag removal	$11,231.15	high Temp Bags
Bag house cages	50.20	
cage cost	12.23	$/cage
Total cage costs	$613.96	$
Equipment Costs (A)	$21,521.50	
Instrumentation	$0.00	0*A
California Sales taxes	$1,829.33	0.085*A
Freight	$1,076.08	0.05*A
Purchase Equipment Cost (**PEC**)	$24,426.90	
Direct & Indirect Installation Costs (DC & IC)	$4,885.38	0.2*PEC
Total Capital Investment (TCI)	$29,312.28	
Direct Annual Costs		
Operating Labor	$ 4,073.40	(.5 hr/shift) (1 shift/8 hrs)(4380 hrs/yr)*$14.88
Supervisor	$ 611.01	15% of operating Labor
Maintenance Labor	$ 4,864.54	(.5 hr/shift) (1 shift/8 hrs)(4380 hrs/yr)*$17.77
Material	$ 4,864.54	100% of maintenance labor
Electricity Baghouse	$ 3,764.83	(0.000181)(3341 acfm)(10.3 in H2O)(4380 hr/yr)($0.138 kW/h)
Electricity Dry Injection Blower	$ 1,813.32	(3 kW)(4380 hr/yr)($0.138 kWh)
Total Annual DC	$ 19,991.64	
Indirect Annual Costs		
Overhead	$ 8,648.09	60% of total labor and material
Admin charges	$ 586.25	2% of TCI
Property Tax	$ 293.12	1% of TCI
Insurance	$ 293.12	1% of TCI
Capital Recovery	$ 2,636.38	
Total Annual IC	$ 12,456.96	
Total Annal Costs (DAC + DIC)	$ 32,448.61	
TAC/tons controlled	**$ 43,849.47**	

Cost Effective Requirements SOx Wet Scrubber

SOx Cost effective Number	18300	$/ton
SOx emissions	0.74	tons/yer
CRF (4% interest and 15 year life)	0.0899411	

SOx Control (Packed Tower) Cost Analysis

Total Capital Investment				Figure 1.4 pg 1-27, Setion 5.2 Post Combstion Controls, Chapter 1 Wet Scrubbers for Acid Gas
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		
Euipment Costs (A)	$ 12,213.00			
Instrumentation (assumed to be included per Section 6, Ch. 2, Table 2.5)	$0.00	0*A		
California Sales taxes	$ 1,038.11	0.085*A		
Freight	$ 610.65	0.05*A		
Purchase Equipment Cost (**PEC**)	$ 13,861.76			
DC	$ 11,782.49	0.85*PEC		
IC	$ 4,851.61	0.35*PEC		
Total Capital Investment (TCI)	$ 30,495.86			
Direct Annual Costs				Table 1.4, pg 1-28, Setion 5.2 Post Combstion Controls, Chapter 1 Wet Scrubbers for Acid Gas
Operating Labor	$ 4,073.40	(.5 hr/shift) (1 shift/8 hrs)(4380 hrs/yr)*$14.88		
Supervisor	$ 611.01	15% of operating Labor		
Solvent (water)				
Caustic replacement				
Watewater disposal				
Maintenance Labor	$ 4,864.54	(.5 hr/shift) (1 shift/8 hrs)(4380 hrs/yr)*$17.77		
Material	$ 4,864.54	100% of maintenance labor		
Electricity	$ 5,439.96	(9 kW)(4380 hr/yr)($0.138 kWh)		
Total AC	$ 19,853.45			
Indirect Annual costs				
Overhead	$ 8,648.09	60% of total labor and material costs		
Admin charges	$ 609.92	2% of TCI		
Property Tax	$ 304.96	1% of TCI		
Insurance	$ 304.96	1% of TCI		
Capital Recovery	$ 2,742.83			
Total IC	$ 12,610.76			
Total annual costs (DC + IC)	$ 32,464.21			
TAC/Ton of SOx controlled	**$ 43,870.55**			

Appendix B

Crematory Potential to Emit

Rating:	4500	cf
	400	lb/hr
	24	hr/day
	19,170,000	cf/year (equivalent to 19,170 MMBtu/year)
	677	tons charge/year

Pollutant	Emission Factor (lb/MMcf)	Maximum Allowable Emissions (lb/day)	(lb/quarter)	(lb/year)
VOC	5.4		0	104
NOx	73	7.9	725	1399
SOx	0.6	0.1	6	12
PM10	7.5	0.8	75	144
PM2.5	7.5	0.8	75	144
CO	82.4	8.9	819	1580

Pollutant	Emission Factor (lb/ton)	Maximum Allowable Emissions (lb/day)	(lb/quarter)	(lb/year)
VOC	0.299	1.4	132	202
NOx	3.56	17.1	1572	2410
SOx	2.17	10.4	958	1469
PM10	4.67	22.4	2062	3162
PM2.5	4.67	22.4	2062	3162
CO	2.95	14.2	1303	1997

Combined:

Pollutant	Maximum Allowable Emissions (lb/day)	(lb/quarter)	(lb/year)	(ton/year)
VOC	1.4	132	306	0.15
NOx	25.0	2297	3810	1.90
SOx	10.5	964	1481	0.74
PM10	23.2	2137	3305	1.65
PM2.5	23.2	2137	3305	1.65
CO	23.1	2121	3577	1.79

Appendix C

Rolling Acres Memorial Garden for Pets Test

Source Emissions Report

Prepared for:

Rolling Acres Memorial Garden for Pets

12200 North Crooked Road
Kansas City, MO 64152
Permit #: 112009-005

By:

Air Analysis Group, Inc.
17 E. Monroe St. #179
Chicago, IL 60603

(618) 394-1400

April 15, 2013

METHOD 5 - DETERMINATION OF PARTICULATE EMISSIONS - RESULTS

Plant Name	Rolling Acres Memorial Gardens	Date	03/20/13
Sampling Location	Kanasas City, MO	Project #	
Operator	Joe Nasseri	Stack Type	Circular

Historical Data						
Run Number		R-1	R-2	R-3	Average	
Run Start Time		13:00	16:00	18:25		hh:mm
Run Stop Time		14:25	17:05	19:38		hh:mm
Meter Calibration Factor	(Y)	0.969	0.969	0.969		
Pitot Tube Coefficient	(C_p)	0.840	0.840	0.840		
Actual Nozzle Diameter	(D_{na})	0.490	0.490	0.580		in
Stack Test Data						
Initial Meter Volume	$(V_m)_i$	321.980	354.590	391.325		ft^3
Final Meter Volume	$(V_m)_f$	354.490	391.100	423.800		ft^3
Total Meter Volume	(V_m)	32.510	36.510	32.475	33.832	ft^3
Total Sampling Time	(□)	60.0	60.0	60.0	60.0	min
Average Meter Temperature	$(t_m)_{avg}$	51.0	56.8	70.4	59.4	°F
Average Stack Temperature	$(t_s)_{avg}$	814.3	1244.1	1493.5	1184.0	°F
Barometric Pressure	(P_b)	29.45	29.45	29.45	29.45	in Hg
Stack Static Pressure	(P_{static})	-0.09	-0.09	-0.09	-0.09	in H_2O
Absolute Stack Pressure	(P_s)	29.44	29.44	29.44	29.44	in Hg
Average Orifice Pressure Drop	$(□H)_{avg}$	1.10	1.36	1.02	1.16	in H_2O
Absolute Meter Pressure	(P_m)	29.53	29.55	29.52	29.54	in Hg
Avg Square Root Pitot Pressure	$(□p^{1/2})_{avg}$	0.23	0.25	0.21	0.23	$(in\ H_2O)^{1/2}$
Moisture Content Data						
Impingers Water Volume Gain	(V_n)	81.0	139.0	115.0	111.7	ml
Impinger Weight Gain	(W_n)	7.1	8.0	7.1	7.4	g
Total Water Volume Collected	(V_{lc})	88.1	147.0	122.1	119.1	ml
Standard Water Vapor Volume	$(V_w)_{std}$	4.147	6.920	5.748	5.605	scf
Standard Meter Volume	$(V_m)_{std}$	32.127	35.699	30.915	32.914	dscf
Calculated Stack Moisture	($B_{ws(calc)}$)	11.4	16.2	15.7	14.4	%
Saturated Stack Moisture	($B_{ws(svp)}$)	100.00	100.0	100.0	100.0	%
Reported Stack Moisture Content	(B_{ws})	11.4	16.2	15.7	14.4	%
Gas Analysis Data						
Carbon Dioxide Percentage	(%CO_2)	6.0	7.9	10.2	8.0	%
Oxygen Percentage	(%O_2)	11.7	10.1	7.1	9.7	%
Carbon Monoxide Percentage	(%CO)	0.0	0.0	0.0	0.0	%
Dry Gas Molecular Weight	(M_d)	29.43	29.67	29.91	29.67	lb/lb-mole
Wet Stack Gas Molecular Weight	(M_s)	28.12	27.77	28.05	27.98	lb/lb-mole
Volumetric Flow Rate Data						
Average Stack Gas Velocity	(v_s)	20.87	25.89	22.69	23.15	ft/sec
Stack Cross-Sectional Area	(A_s)	2.41	2.41	2.41		ft^2
Actual Stack Flow Rate	(Q_{aw})	3013	3736	3274	3341	acfm
Wet Standard Stack Flow Rate	(Q_{sw})	74	68	52	65	wkscfh
Dry Standard Stack Flow Rate	(Q_{sd})	1088	954	734	925	dscfm
Percent of Isokinetic Rate	(I)	90.4	114.5	92.0	99.0	%
Emission Rate Data						
Mass of Particulate on Filter	(m_f)	7.750000000	16.700000000	27.750000000	17.400000000	mg
Mass of Particulate in Acetone	(m_a')	7.700000000	5.300000000	10.300000000	7.766666667	mg
Mass due to Acetone Blank	(W_a)	0.00000	0.00000	0.00000	0.00000	mg
Total Mass of Particulates	(m_n)	15.450000000	22.000000000	38.050000000	25.166666667	mg
Stack Particulate Concentration	(c_s)	0.000480905	0.000616260	0.001230789	0.000775985	g/dscf
	(c_s)	0.007421505	0.009510357	0.018993996	0.011975286	gr/dscf
Particulate Emission Rate	(E)	0.031390842	0.035281900	0.054233220	0.040301987	kg/hr
	(E)	0.069205017	0.077783338	0.119563881	0.088850745	lbs/hr

FACILITY DESCRIPTION

The facility tested is an Animal Incinerator. This plant includes the following equipment:

EQUIPMENT	MANUFACTURED BY	MODEL
Incinerator	Matthews	IEB Series 56

The fuel used for the incinerator during testing was natural gas.

PROCESS OPERATION

On March 20, 2013, the following process data was recorded by the plant operators:

TEST RUN NUMBER	BURN TEMPERATURE AT START (^{O} F)	TEMPERATURE AT THE END (^{O} F)	AVERAGE TEMPERATURE (^{O} F)
Run 1	1400	1550	1475
Run 2	1675	1675	1675
Run 3	1775	1775	1775

The weight processed was approximately 2,488 pounds.