

CATEGORY:

**INCINERATOR/CREMATORY**

BACT Size:

**CREMATORY - HUMAN**

<b>BACT Determination Number:</b> 212	<b>BACT Determination Date:</b> 1/3/2020
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**Equipment Information**

**Permit Number:** N/A -- Generic BACT Determination  
**Equipment Description:** CREMATORY - HUMAN  
**Unit Size/Rating/Capacity:**  
**Equipment Location:**

**BACT Determination Information**

<b>ROCs</b>	<b>Standard:</b>	None
	<b>Technology Description:</b>	Use of natural gas and a secondary combustion Chamber (afterburner) => 1600F
	<b>Basis:</b>	
<b>NOx</b>	<b>Standard:</b>	60 PPM @ 3% O2
	<b>Technology Description:</b>	or 0.73 lb/MMBTU
	<b>Basis:</b>	
<b>SOx</b>	<b>Standard:</b>	None
	<b>Technology Description:</b>	Natural gas fired
	<b>Basis:</b>	
<b>PM10</b>	<b>Standard:</b>	None
	<b>Technology Description:</b>	Use of natural gas and a secondary combustion Chamber (afterburner) => 1600F
	<b>Basis:</b>	
<b>PM2.5</b>	<b>Standard:</b>	None
	<b>Technology Description:</b>	
	<b>Basis:</b>	
<b>CO</b>	<b>Standard:</b>	None
	<b>Technology Description:</b>	Use of natural gas and a secondary combustion Chamber (afterburner) => 1500F
	<b>Basis:</b>	
<b>LEAD</b>	<b>Standard:</b>	
	<b>Technology Description:</b>	
	<b>Basis:</b>	

**Comments:** None

**District Contact:**

Note to file:

A Public notice was started in BACT 212 on December 2, 2018. It concluded on January 2, 2020. No comments were received.

Venk Reddy

1/7/20



**BEST AVAILABLE CONTROL TECHNOLOGY & TOXIC BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION**

**DETERMINATION NO.:** 212

**DATE:** November 22, 2019

**ENGINEER:** Venk Reddy

**Category/General Equip Description:** Human Crematory

**Equipment Specific Description:** Human Crematory

**Equipment Size/Rating:** Minor Source BACT

**Previous BACT Det. No.:** 133 & 74

This BACT determination will update determination # 133 for a Human crematory

**BACT ANALYSIS**

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

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

District/ Agency	Best Available Control Technology (BACT) Requirements
US EPA	<b>BACT</b> <a href="#">Source: EPA/ RACT/BACT/LEAR Clearinghouse</a>
	Crematory
	<b>VOC</b> No Standard
	<b>NOx</b> No Standard
	<b>SOx</b> No Standard
	<b>PM10</b> No Standard
	<b>PM2.5</b> No Standard
	<b>CO</b> No Standard
	<b>Rule Requirements</b> None
	No New BACT determinations entered into the Clearinghouse nor any additional rules as of 4-3-19.

District/ Agency	Best Available Control Technology (BACT)/ Requirements														
ARB	<p><b>BACT</b>  <a href="#">Source: ARB BACT Clearinghouse</a></p> <table border="1"> <tr> <td colspan="2">Crematory</td> </tr> <tr> <td><b>VOC</b></td> <td>No Standard</td> </tr> <tr> <td><b>NOx</b></td> <td>No Standard</td> </tr> <tr> <td><b>SOx</b></td> <td>No Standard</td> </tr> <tr> <td><b>PM10</b></td> <td>No Standard</td> </tr> <tr> <td><b>PM2.5</b></td> <td>No Standard</td> </tr> <tr> <td><b>CO</b></td> <td>No Standard</td> </tr> </table> <p><b>Rule Requirements</b>            None</p> <p>No New BACT determinations entered into the Clearinghouse nor any additional rules as of 4-3-19.</p>	Crematory		<b>VOC</b>	No Standard	<b>NOx</b>	No Standard	<b>SOx</b>	No Standard	<b>PM10</b>	No Standard	<b>PM2.5</b>	No Standard	<b>CO</b>	No Standard
Crematory															
<b>VOC</b>	No Standard														
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<b>SOx</b>	No Standard														
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<b>PM2.5</b>	No Standard														
<b>CO</b>	No Standard														

District/ Agency	Best Available Control Technology (BACT)/ Requirements														
SMAQMD	<p><b>BACT</b></p> <table border="1"> <tr> <td colspan="2">From SMAQMD BACT #133 issued on 8/12/16</td> </tr> <tr> <td>VOC</td> <td>Natural gas fuel and a secondary combustion chamber (afterburner) =&gt; 1600 °F</td> </tr> <tr> <td>NOx</td> <td>60 ppmv corrected to 3% O2 or 0.073 lb/MMBTU, measured as emissions from the fuel burning, not with the charge.</td> </tr> <tr> <td>SOx</td> <td>Natural gas fired</td> </tr> <tr> <td>PM10</td> <td>Natural gas fired with secondary chamber operating at &gt;1600 °F</td> </tr> <tr> <td>PM2.5</td> <td>No Standard</td> </tr> <tr> <td>CO</td> <td>Secondary Chamber =&gt; 1500 °F</td> </tr> </table> <p><b>Rule Requirements</b></p> <p><a href="#">Rule 419</a>- NOx from Miscellaneous Combustion Units. New Crematories fired at greater than 1200 °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% O2 for NOx and 400 ppmv corrected to 3% O2 for CO</p>	From SMAQMD BACT #133 issued on 8/12/16		VOC	Natural gas fuel and a secondary combustion chamber (afterburner) => 1600 °F	NOx	60 ppmv corrected to 3% O2 or 0.073 lb/MMBTU, measured as emissions from the fuel burning, not with the charge.	SOx	Natural gas fired	PM10	Natural gas fired with secondary chamber operating at >1600 °F	PM2.5	No Standard	CO	Secondary Chamber => 1500 °F
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District/ Agency	Best Available Control Technology (BACT)/ Requirements														
South Coast AQMD	<p><b><u>BACT</u></b></p> <table border="1" data-bbox="472 352 1414 615"> <tr> <td colspan="2">From SCAQMD BACT Guidelines for Non Major Polluting Facilities Rev 1 Date: 2-1-2019</td> </tr> <tr> <td><b>VOC</b></td> <td>Natural gas fired, Secondary Chamber ≥ 1500 °F</td> </tr> <tr> <td><b>NOx</b></td> <td>60 ppm compliance with Rule 1147</td> </tr> <tr> <td><b>SOx</b></td> <td>Natural gas fired</td> </tr> <tr> <td><b>PM10</b></td> <td>Natural gas fired, Secondary Chamber ≥ 1500 °F</td> </tr> <tr> <td><b>PM2.5</b></td> <td>No Standard</td> </tr> <tr> <td><b>CO</b></td> <td>No Standard</td> </tr> </table> <p><b><u>Rule Requirements</u></b>  <a href="#">Rule 1147</a> NOx Reductions from Miscellaneous Sources – New Crematories fired at greater than 1200 °F cannot exceed 60 ppm corrected to 3% O2 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.</p> <p>BACT determination was updated to reflect Rule 1147 requirement.</p>	From SCAQMD BACT Guidelines for Non Major Polluting Facilities Rev 1 Date: 2-1-2019		<b>VOC</b>	Natural gas fired, Secondary Chamber ≥ 1500 °F	<b>NOx</b>	60 ppm compliance with Rule 1147	<b>SOx</b>	Natural gas fired	<b>PM10</b>	Natural gas fired, Secondary Chamber ≥ 1500 °F	<b>PM2.5</b>	No Standard	<b>CO</b>	No Standard
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<b>PM2.5</b>	No Standard														
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District/ Agency	Best Available Control Technology (BACT)/ Requirements														
San Diego County APCD	<p><b><u>BACT</u></b></p> <table border="1" data-bbox="472 1089 1414 1352"> <tr> <td colspan="2">From SDCAPCD NSR Requirements for BACT</td> </tr> <tr> <td><b>VOC</b></td> <td>No Standard</td> </tr> <tr> <td><b>NOx</b></td> <td>No Standard</td> </tr> <tr> <td><b>SOx</b></td> <td>No Standard</td> </tr> <tr> <td><b>PM10</b></td> <td>No Standard</td> </tr> <tr> <td><b>PM2.5</b></td> <td>No Standard</td> </tr> <tr> <td><b>CO</b></td> <td>No Standard</td> </tr> </table> <p><b><u>Rule Requirements</u></b>  None</p> <p>No New BACT determinations entered into the Clearinghouse nor any additional rules as of 4-3-19.</p>	From SDCAPCD NSR Requirements for BACT		<b>VOC</b>	No Standard	<b>NOx</b>	No Standard	<b>SOx</b>	No Standard	<b>PM10</b>	No Standard	<b>PM2.5</b>	No Standard	<b>CO</b>	No Standard
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<b>CO</b>	No Standard														

District/ Agency	Best Available Control Technology (BACT)/ Requirements
Bay Area AQMD	<a href="#">BACT</a>
	From BAAQMD BACT Guideline – Crematory Revision 1 Date: 9/12/2007
	<b>VOC</b> Secondary Combustion ≥ 1500 °F
	<b>NOx</b> Natural Gas Fired
	<b>SOx</b> Natural Gas Fired
	<b>PM10</b> Secondary Combustion ≥ 1600 °F (set Point at 1650 °F)
	<b>PM2.5</b> No Standard
	<b>CO</b> Secondary Chamber ≥ 1500 °F
	<b>Rule Requirements</b> None
	No New BACT determinations entered into the Clearinghouse nor any additional rules as of 4-3-19.

District/ Agency	Best Available Control Technology (BACT)/ Requirements
San Joaquin Valley APCD	<a href="#">BACT</a>
	From SJVAPCD BACT Guidelines – Crematory – Natural Gas Fired 1.9.3 Date: 6/1/2005
	<b>VOC</b> Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1600 °F
	<b>NOx</b> Natural gas fired
	<b>SOx</b> Natural gas fired
	<b>PM10</b> Natural gas fired and a secondary combustion chamber (afterburner) ≥ 1600 °F
	<b>PM2.5</b> No Standard
	<b>CO</b> No Standard
	<b>Rule Requirements</b>  <a href="#">Rule 4302 Incinerator Burning</a> 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 <a href="#">Rule 1020</a> defines a multi chamber incinerator as that used to dispose of combustible refuse by burning. Since human remains are not considered refuse, this definition and thus Rule 4302 is not applicable to this source category.
	No New BACT determinations entered into the Clearinghouse nor any additional rules as of 4-3-19.

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

<b>SUMMARY OF ACHIEVED IN PRACTICE CONTROL TECHNOLOGIES</b>	
<b>VOC</b>	1) Natural gas fired and a secondary combustion chamber (afterburner) ≥ 1600 °F, SMAQMD, SJVUAPCD 2) Natural gas fired and a secondary combustion chamber (afterburner) ≥ 1500 °F, SCAQMD, BAAQMD
<b>NOx</b>	1) 60 ppmv corrected to 3% O2 or 0.073 lb/MMBTU measurement of the fuel burned only, SMAQMD, SCAQMD 2) Natural gas fired, BAAQMD, SJVUAPCD
<b>SOx</b>	Natural gas fired, SMAQMD, SCAQMD, BAAQMD, SJVUAPCD
<b>PM10</b>	1) Natural gas fired with secondary chamber operating at ≥1600 °F SMAQMD, SJVAPCD, BAAQMD 2) Natural gas fired with secondary chamber operating at ≥ 1500 °F, SCAQMD
<b>PM2.5</b>	No Standard
<b>CO</b>	1) 400 ppmv corrected to 3% O2 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. 2) Secondary chamber operating at ≥ 1500 °F, BAAQMD

**CO**

The 400 ppmv corrected to 3% O2 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 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:

<b>BEST CONTROL TECHNOLOGIES ACHIEVED</b>		
<b>Pollutant</b>	<b>Standard</b>	<b>Source</b>
VOC	Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1600 °F	SMAQMD, SJVUAPCD
NOx	60 ppmv correct to 3% O2 or 0.073 lb/MMBTU	SMAQMD, SCAQMD
SOx	Natural Gas Fired	SCAQMD, SMAQMD, BAAQMD, SJVAPCD
PM10	Natural gas fired with secondary chamber operating at ≥ 1600 °F	SMAQMD, SJVAPCD, BAAQMD
PM2.5	No Standard	
CO	Secondary chamber operating at ≥ 1500 °F	

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

The cost recovery factor (CRF) used in determining cost effectiveness in the previous BACT #133 assumed and annual interest rate of 5%. Per the October 2015, "Procedures for Making Best Available Control Technology (BACT) and Best Available Control Technology for Toxics (T-BACT) Determinations for new and Modified Emission Units" the interest rate used to calculate the CRF is the 6 month average of the ten year treasury + 2% rounded up. As of April 2019, 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 October 2018 and ending in April 2019 is 3.15%, 3.12%, 2.83%, 2.71%, 2.68, and 2.52%. The average is 2.84%. Therefore the resultant annual interest rate to be used is  $2.84\% + 2\% = 4.84\%$  or 5%. Since there is no change in the interest rate, there is no change in the cost effective calculations from the original evaluation.

**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 SO<sub>x</sub>, the use of a baghouse and venturi scrubber for the control of PM<sub>10</sub> and the use of an SCR or a low NO<sub>x</sub> burner for the control of NO<sub>x</sub>. 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 NO<sub>x</sub> 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 an SCR, low NO<sub>x</sub> 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.

**NO<sub>x</sub>:**

A cost effectiveness analysis was done to determine if an SCR system could be considered cost effective to control the NO<sub>x</sub> 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 NO<sub>x</sub> at less than 60 ppmv. To estimate the NO<sub>x</sub> 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 NO<sub>x</sub> is 3.56 lb of NO<sub>x</sub> per ton of charge. As a worst case assumption, and consistent with the crematory permitting manual of the BAAQMD, the NO<sub>x</sub> emission factor that is used in this analysis will be the combined emission factor of 5.31 lb of NO<sub>x</sub>/ton of charge which includes the emission factor of natural gas combustion added to the emission factor from burning of the charge.

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 NO<sub>x</sub> control efficiency of 90%, the NO<sub>x</sub> emissions from the crematory is calculated to be 0.1 tons per year ( $421 * 5.31 * (1 - 0.9) / 2000 = 0.1$ ).

A cost for a SCR system was estimated using EPA's Cost Control Manual, 6<sup>th</sup> 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 two identical crematory units and



a calculated equivalent burner rating.

The total annualized cost for the SCR system is estimated to be \$49,295.46. The total NOx controlled would be 1.01 tons per year ( $421 \times 5.31 \times 0.9 / 2000 = 1.01$ ). The analysis shows the cost effectiveness calculation to be \$48,997.36 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
\$49,295.46	1.01	\$48,997.36	\$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. Based on source testing of a similar crematory unit, only about 23% of the total particulate collected is filterable. Therefore, this analysis will assume that the baghouse will collect 100% of the filterable emissions which would be approximately 0.06348 tons/yr. With the District's particulate cost effectiveness threshold of \$11,400/ton, interest rate of 5% and an equipment life of 10 years, the capital cost for the control would have to be less than \$5,588 to be considered cost effective.

Based on EPA's Cost Control Manual, 6<sup>th</sup> Edition, the capital cost of a baghouse needed to control the flow characteristics of a crematory is estimated to be approximately \$21,499.74. Since the capital costs of a baghouse alone are approximately 4 times 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
\$2,784.31	0.063	\$43,861.29	\$11,400	No

A screening cost effective analysis was done for a venturi scrubber using the EPA Cost Control Manual, 6<sup>th</sup> 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 3337 cfm of exhaust gas is estimated to cost \$82,572 which only takes into account the equipment costs. The cost effectiveness for this system would then be \$38,745 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
\$10,693.48	0.276	\$38,744.51	\$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, 6<sup>th</sup> 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 \$27,308 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 \$59,365.10 and therefore is not considered to be cost effective.

Total Annualized Cost of Wet Scrubber	Quantity of SOx Controlled per yr	Cost of wet scrubber per ton removed	SMAQMD cost effective threshold for Sox	Cost effective
\$27,307.95	0.46 tons	\$59,365.10	\$18,300	No

The EPA Cost Control Manual, 6<sup>th</sup> 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 was not considered in this analysis. The total annualized costs are estimated to be \$23,265.11. The cost per ton of SOx removed is calculated to be \$50,576.33 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
\$23,265.11	0.46	\$50,576.33	\$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

$$\begin{aligned} \text{Max Cost} &= (0.276 \text{ ton PM}_{10}/\text{yr} \times \$11,400/\text{ton PM}) + (0.46 \text{ ton SO}_x/\text{yr} \times \$18,300/\text{ton SO}_x) \\ &= \$11,564.40/\text{yr} \end{aligned}$$

Since the annualized costs of a wet scrubber or a dry scrubber with baghouse is \$27,307.95 and/or \$23,265.11 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	\$27,307.95	0.46 tons SOx 0.276 tons PM10	\$11,564.40	No
Dry Scrubber with Baghouse	\$23,265.11	0.46 tons SOx 0.276 tons PM10	\$11,564.40	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 Human Crematory		
Pollutant	Standard	Source
VOC	Natural gas fuel and a secondary combustion chamber (afterburner) ≥ 1600 °F	SMAQMD, SJVAPCD
NOx	60 ppmv corrected to 3% O2 or 0.073 lb/MMBTU, measured as emissions from the fuel burning, not with the charge.	SMAQMD, SCAQMD
SOx	Natural Gas Fired	SCAQMD, SMAQMD, BAAQMD, SJVAPCD
PM10	Natural gas-fired with secondary chamber operating at ≥ 1600 °F	SMAQMD, SJVAPCD, BAAQMD
PM2.5	No Standard	
CO	Secondary Chamber ≥ 1500 °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.

REVIEWED BY: \_\_\_\_\_ DATE: \_\_\_\_\_

APPROVED BY: Ben F. [Signature] DATE: 11-22-19

## 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 = \$ 48,997.36 \$/ton**

## Equipment

Crematory rating	5.914481559 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 Stoichiometric Ratio	1.05					
Stored Ammonia Conc	29 %					
Ammonia 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	Buffalo Cremation		Lifeplan Cremations		AVE
Cost year	1998	9/18/2008	1316	1/1/2011	1336.8	1333.6
Equipment Life	10 years	1241		1199		1297.783
Annual Interest Rate	5 %					
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					

## Crematory Calculations

Q <sub>g</sub>	5.914481559 mmBTU/hr					
Q <sub>flow gas</sub>	3337.4 acfm	3904.7	3445.7	3754	2954	2976
N <sub>Nox</sub>	0.9					3010
						3337.4

## SCR Reactor Calculations

V <sub>ol Catalyst</sub>	134.1927791 ft3
A <sub>Catalyst</sub>	3.476458333 ft2
A <sub>SCR</sub>	3.997927083 ft2
L=W=	1.999481704 ft
n <sub>layer</sub>	12
n <sub>layer</sub>	4.216702322
n <sub>total</sub>	13
n <sub>SCR</sub>	154.8171302 ft

## Reagent Calculations

m <sub>Reagent</sub>	0.51144438 lb/hr
m <sub>sol</sub>	1.763601312 lb/hr
Q <sub>sol</sub>	0.23559824 gph
Tank Volume	508.8921974 gal

## Cost Estimation

### Direct Costs

DC	\$ 219,976.07
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### Indirect Costs

General Facilities	\$ 10,998.80
Engineering and home office fees	\$ 21,997.61
Process Contingency	\$ 10,998.80
Total Indirect Installation Costs	\$ 43,995.21
Project Contingency	\$ 39,595.69
Total Plant Cost	\$ 303,565.98
Preproduction Cost	\$ 6,071.34
Inventory Capital	\$ 384.75
Total Capital Investment	\$ 310,023.07

### Direct Annual Costs

Maintenance Costs	\$ 4,650.35 per yr
Power	5.092523878 KW
Annual Electricity	\$ 1,905.64 per yr
Reagent Solution Cost	\$ 1,560.36 per yr

### Catalyst Replacement

FWF	0.317208565
Annual Catalyst Replacement	\$ 1,028.70 per yr

Total Variable Direct Cost	\$ 4,495.71 per yr
Total Direct Annual Cost	\$ 9,146.06 per yr

### CRF

Indirect Annual Cost	\$ 40,149.41 per yr
Total annual Cost	\$ 49,295.46 per yr

NOx Removed 1.01 tons per year

Cost of Nox controlled per ton removal \$ 48,997.36 per ton

	3.56 NOX lb/ton(A)	225 lb/hr (B)
	(A) - Table 2.3-1 AP-42,	
	2.3 Medical Waste	(B) Burn rate of the crematory
	Incineration	
	1.75 NOx lb/ton (C)	
	(C) - Natural gas combustion at 60 ppm	
	5.31 Combined NOx lb/ton	
	lb of NOx based on	
tons of charge based on 12 hrs a day 6 days a week 52 weeks a	3.56 lb of NOx/ ton of	
year and burn rate of crematory	charge	LB of NOx controlled based on 90%
421 tons	1.12 tons	1.01 tons

**PM10 Baghouse Cost Effective Requirements**

PM Cost effective Number	11400 \$/ton
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PM emission from Crematory 23% of PM is filterable	0.06348 tons/yer
Cost needed to be cost effective	\$ 723.67 \$
CRF (5% interest and 10 year life)	0.12950457
<b>P (Cost of control need to be cost effective)</b>	<b>5588.00336</b>

Total PM =  
0.276 ton/year

**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 \$
<b>Purchased equipment costs</b>	<b>\$ 21,499.74 \$</b>
Annualized Cost	\$ 2,784.31
Cost effectiveness	\$ 43,861.29 \$/Ton controlled



**Cost Effective Requirements SOx Dry Scrubber**

SOx Cost effective Number	18300 \$/ton	
SOx emissions	0.46 tons/yer	0.46
CRF (5% interest and 10 year life)	0.129504575	

**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 <sup>2</sup>
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 \$ 23,265.11

TAC/tons controlled \$ 50,576.33

**Cost Effective Requirements SOx Wet Scrubber**

SOx Cost effective Number	18300 \$/ton
SOx emissions	0.46 tons/yer
CRF (5% interest and 10 year life)	0.129504575

Figure 1.4 pg 1-27, Setion 5.2  
Post Combstion Controls,  
Chapter 1 Wet Scrubbers for  
Acid Gas

**SOx Control (Packed Tower) Cost Analysis**

**Total Capital Investment**

Tower Cost	\$ 7,935.00	69 ft^2
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	

Equation 1.40 pg 1-24, Setion  
5.2 Post Combstion Controls,  
Chapter 1 Wet Scrubbers for  
Acid Gas

**Direct Annual Costs**

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	\$ 27,307.95	
TAC/Ton of Sox controlled	\$ 59,365.10	

Table 1.4, pg 1-28, Setion 5.2  
Post Combstion Controls,  
Chapter 1 Wet Scrubbers for  
Acid Gas

**PM10 Venturi Cost Effective Analysis**

Total PM 0.276 Tons/year  
PM Cost effectiveness 11400 \$/tons controlled  
CRF (5% interest and 10 year life) 0.1295046

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	$150 * Q(\text{sat})^{0.56}$	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	$0.56 * \text{PEC}$		
Total Indirect Costs, IC	\$10,480.77	$0.35 * \text{PEC}$		
Total	\$82,572.25			
Total Annualized Cost	\$10,693.48			
Cost Effectiveness	\$38,744.51	\$/Ton Controlled		