San Joaquin Valley
Unified Air Pollution Control District

Best Available Control Technology (BACT) Guideline 5.4.14*

Last Update 10/6/2009

Wine Fermentation Tank

Pollutant	Achieved in Practice or contained in the SIP	Technologically Feasible	Alternate Basic Equipment
VOC	Temperature-Controlled Open Top Tank with Maximum Average Fermentation Temperature of 95 deg F	1. Capture of VOCs and Thermal Oxidation or Equivalent (88% control) 2. Capture of VOCs and Carbon Adsorption or Equivalent (86% control) 3. Capture of VOCs and Absorption or Equivalent (81% control) 4. Capture of VOCs and Condensation or Equivalent (81% control)	

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

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

Top Down BACT Analysis for Wine Fermentation VOC Emissions for Permit Units C-447-330-1 through '341-1

Step 1 - Identify All Possible Control Technologies

BACT guideline 5.4.14 (10/6/2009) lists both absorption (scrubber) and condensation systems as technologically feasible options for the control of VOC emission from wine fermentation operations. Since 2009, there has been substantial development of these two control technologies prompting a re-examination of the feasibility of these technologies in this project to determine if the technologies are considered Achieved in Practice. The Achieved in Practice analysis for BACT for wine fermentation tanks is included in Attachment B and is as follows:

The SJVUAPCD BACT Clearinghouse guideline 5.4.14, 1st quarter 2015, identifies technologically feasible BACT for wine fermentation tanks as follows:

1) Capture of VOCs and thermal oxidation or equivalent (88% control)
2) Capture of VOCs and carbon adsorption or equivalent (86% control)
3) Capture of VOCs and absorption or equivalent (81% control)
4) Capture of VOCs and condensation or equivalent (81% control)

Step 2 - Eliminate Technologically Infeasible Options

None of the above listed technologies are technologically infeasible.

Step 3 - Rank Remaining Control Technologies by Control Effectiveness

Rank by Control Effectiveness		
Rank	Control	Overall Capture and Control Efficiency(*)
1	Capture of VOCs and thermal or catalytic oxidation or equivalent	88%(**)
2	Capture of VOCs and carbon adsorption or equivalent	86%
3	Capture of VOCs and absorption or equivalent	81%
4	Capture of VOCs and condensation or equivalent	81%
5	Temperature-Controlled Open Top Tank with Maximum Average Fermentation Temperature of 95 deg F	Baseline (Achieved-in-Practice)

(*) Capture efficiency (90%) x removal efficiency for control device.
(**) Following recent District practice, thermal and catalytic oxidation will be ranked together.

Step 4 - Cost Effectiveness Analysis

A cost-effective analysis is performed for each control technology which is more effective than meeting the requirements of option 5 (achieved-in-practice BACT), as proposed by the facility.

Maximum Vapor Flow Rate

Based on the kinetic model provided by the facility, maximum CO2 production rate for each fermentation tank = 1803.9 scfm.

Maximum Vapor Flow Rate = 1803.9 scfm x 12 fermentation tanks = 21,649 scfm

The submitted kinetic model is based upon a maximum rate 46-hour red wine fermentation with a maximum tank charge of 80% of the nominal tank capacity of 350,000 gallons (280,000 gallons of must fermented). Since the planned operation of the proposed tanks (per E & J Gallo Winery) is the production of commercial premium wines with fermentation cycles of 5-8 days, the 46 hour fermentation basis with maximum fill is a very conservative upper limit of the expected flow rate.

Uncontrolled Fermentation Emissions

For purposes of cost effectiveness analysis, uncontrolled fermentation emissions will be calculated based on the uncontrolled emission factors without consideration of the 35% reduction per Rule 4694 as these are the actual uncontrolled emissions being sent to each control technology option.

Uncontrolled Fermentation PE = EF_{red} (lb-VOC/1000 gal) x annual throughput (gal/yr) x 12 tanks
= 6.2 lb-VOC/1000 gal x 812,000 gal/year x 12 tanks
= 5,034 lb-VOC/year x 12 tanks
= 60,408 lb-VOC/year

Capture of VOCs and condensation (> 81% collection & control)

Design Basis

- The District provided notice to Steven Colome, Sc.D. of EcoPAS that this project was being proposed to allow EcoPAS an opportunity to provide cost information. The District did not receive updated cost information.
- Although the EcoPAS units have not been demonstrated at the scale of operation as proposed by this project, the District will conservatively assume that the proposed equipment and equipment cost proposed by EcoPAS will meet the duty requirements for the project.
- EcoPAS has provided site-specific installation costs for the proposed scope of supply (see project N-1131615 Attachment C). The District will conservatively base the cost effectiveness analysis on these costs with the exception of the following adjustments:
- Engineering costs will be assumed to be 5% of total direct cost exclusive of city/county plan check costs. The District believes that this value reflects a typical minimum for any significant industrial project and believes that this is consistent with standard estimating and good engineering practice.

- The EcoPAS cost for Permits and Testing ($10,000) is considered adequate to cover building department costs only, including plan check and building permit fees. Due to the unsteady state operation of fermentation tanks, initial source testing is expected to be a significant technical operation with significant expense, conducted over the fermentation cycle rather than the typical three 30-minute steady state measurements. An additional cost of $15,000 per unit will be assumed for initial source testing.
- EcoPAS has estimated a cost of $98,100 to cover administrative cost and contingency for the project. The District's analysis will consider these items separately as "Owner's Cost" (administrative) and "Project Contingency".
- Owner's Cost: The District considers a value of $100,000 as a minimum value to cover the project management, internal engineering and operations planning required to implement a significant new process technology of this scale in a commercial winery.
- Project Contingency: Good engineering practice and accepted norms of the engineering industry, when applied to an conceptual estimate of this type, require a project contingency exceeding 20%. Contingencies less than 10% are only achieved when preliminary engineering has been completed (all major equipment fully specified and firm quotations received with approved piping and instrumentation diagrams, plot plans and equipment layouts) plus a preliminary design basis and/or preliminary design sketches with material take-off for all significant cost components of the project. Contingencies less than 5% are only applicable to projects for which all engineering is completed and approved for construction. Based on this discussion, the District will apply a conservative project contingency of 20% to the estimated capital investment for this project.
- E & J Gallo Winery has indicated that, consistent with their current plant and corporate operating philosophy, programable logic controls and data logging as well as integration with existing digital control systems will be required for any fermentation control system installed. The District has added an allowance of $10,000 per unit to cover the expected hardware and programming cost of this item.
- Operating labor is estimated based on 1 operator hour per day and 3 shifts per day per operating unit over a 90 day crush season and an hourly cost of $18.50 per hour.
- An allowance for annual maintenance cost was included as 1% of Total Capital Investment.
- The cost of a chiller system has been annualized and the annualized cost is estimated at $270 per ton of recovered ethanol based on approximately $85 per ton energy charge at $0.13/kWh and $100 per ton capital charge for the central chilled water facility (based on a District analysis of annualized costs for a 100 ton mechanical chiller).
- Annual source testing will be required. It is assumed that only one representative unit will require testing each year. An annual charge of $15,000 has been included.
- EcoPAS has indicated the value of the recovered ethanol is $25 per gallon as a 60 proof alcohol spirit. However, E & J Gallo Winery has indicated the highest value for this product would be $[redacted] per gallon assuming the alcohol can be used for internal brandy production (which has not been demonstrated in practice to be true). This represents the facilities internal cost for distilling material alcohol and does not include additional processing. If the alcohol cannot be used internally, E & J Gallo Winery has indicated the product has no value outside the organization and would in fact incur a disposal cost resulting in a value less than $0 per gallon. E & J Gallo Winery has proposed to value the recovered alcohol at a conservative value of $[redacted] per gallon until it can be proven in practice to have a greater value.

Equipment Cost Refrigerated Condenser

Pricing for the EcoPAS units will be based on pricing previously received from EcoPAS LLC for District Project N-1131615.

In project N-1131615, EcoPAS sized one condenser to handle six 56,000 gallon tanks (total volume of 336,000 gallons) with a combined flow rate of 1,731.6 scfm (288.6 scfm x 6 tanks) and a combined VOC emission rate of 21,216 lb-VOC/year (3,536 lb-VOC/year x 6 tanks). The EcoPAS condenser proposed was not actually capable of actually handling the maximum flowrate but depended instead on the operational diversity of the six connected tanks to result in an actual combined peak flow less than the maximum since all six tanks would not achieve peak design flow simultaneously. Each tank in this project has a capacity of 350,000 gallons, a flow rate of 1,803.9 scfm, and an emission rate of 5,034 lb-VOC/year. Since it is a single tank with no operational diversity as mentioned above, the control device must be actually sized to handle the full rated flow. Therefore, using the capital cost of one condenser sized for the operation in project N-1131615 would be conservative as that condenser would be undersized to handle each tank in this project. As a conservative assumption, for this BACT analysis one condenser will serve each individual tank.

As quoted by EcoPAS, based on supply of 4 PAS units each sized to control six (6) 56,000-gallon tanks, the price per condenser is estimated at $475,318 each. The estimated price includes shipping and California sales tax.

Equipment Cost= $475,318

In this project, one condenser will serve each of the twelve tanks,

Total Equipment Cost = $475,318 x 12 units
= $5,703,816

All other costs (direct, indirect, and annual) will be taken from project N-1131615 and will be considered conservative for this project as there are more condenser units (12 units) assumed for this BACT analysis compared to project N-1131615 (4 units).

Condensation	
Cost Description	Cost ($)
Cost of Refrigerated Condenser system (12 PAS Units)	$5,703,816
The following cost data is taken from EPA Control Cost Manual, Sixth Edition (EPA/452/B-02-001).	
Direct Costs (DC)	
Base Equipment Costs (Condenser) See Above	$5,703,816
Instrumentation (included)	-
Sales Tax 3% (included)	-
Freight (included)	-
Purchased equipment cost	**$5,703,816**
Labor (per EcoPAS estimate)	$81,600
Installation Expense (per EcoPAS estimate)	$59,175
Subcontracts (per EcoPAS estimate)	$18,000
PLC/Programming	$40,000
Direct installation costs	**$198,775**
Total Direct Costs (TDC)	**$5,902,591**
Indirect Costs (IC)	
Engineering (5% of TDC)	$295,130
Permits (Building Department) (Allowance)	$10,000
Initial Source Testing (12 units x $15,000/unit)	$180,000
Owner's Cost (Allowance)	$100,000
Total Indirect Cost (TIC)	**$585,130**
Subtotal Capital Investment (SCI = TDC + TIC)	**$6,487,721**
Project Contingency (20% of SCI)	$1,297,544
Total Capital Investment (TCI) (TDC + TIC + Contingency)	**$7,785,265**

Annualized Capital Costs

Annualized Capital Investment = Initial Capital Investment x Amortization Factor

Amortization Factor = $\left[\frac{0.1(1.1)^{10}}{(1.1)^{10}-1}\right]$ = 0.1627, amortizing over 10 years at 10%

Therefore,

Annualized Capital Investment = $7,785,265 x 0.1627 = $1,267,016

Annual Costs

Annual Costs			
Direct Annual Cost (DC)			
Operating Labor			
Operator	1 hr/shift x 3 shifts/day x 12 units x 90 days = 3,240 hr/year	$18.50/h	$59,940
Supervisor	15% of operator		$8,991
Maintenance			
Labor	1% of TCI		$77,853
Chiller (Glycol)			
	60,408 lb/year (uncontrolled fermentation emissions) x 0.81 ÷ 2000	$270/ton EtOH	$6,606
Utility			
Electricity		$0.102/kWh	$0
Total DC			**$59,758**
Indirect Annual Cost (IC)			
Overhead	60% of Labor Cost	0.6 x ($59,940 + $8,991 + $77,853)	$88,070
Administrative	2% TCI		$155,705
Property Taxes	1% TCI		$77,853
Insurance	1% TCI		$77,853
Annual Source	One representative test/year @ $15,000		$15,000
Total IC			**$414,481**
Recovery Credits (RC)			
80 Proof Recovered	60,408 lb/year (uncontrolled fermentation emissions) x 0.81 x gal/6.62 lb ÷ 0.40	$[redacted]/gal 80 Proof EtOH	$[redacted]
Annual Cost (DC + IC – RC)			$[redacted]

Total Annual Cost = Condenser System + Annual Cost
= $1,267,016 + $[redacted]
= $[redacted] (with Recovery Credits)

Emission Reductions

EcoPAS has indicated the PAS unit is capable of achieving a capture and control efficiency of 90%. However, the District's current BACT Guideline identifies a combined capture and control efficiency of 81% for condensation technology. The capture and control efficiency of 81% will be used in this analysis as the value of 90% has yet to be shown to be feasible.

Annual Emission Reduction = Fermentation Emissions x 0.81
= 60,408 lb-VOC/year x 0.81
= 48,930 lb-VOC/year
= 24.465 tons-VOC/year

Cost Effectiveness

Cost Effectiveness = Total Annual Cost ÷ Annual Emission Reductions

Cost Effectiveness = $[redacted]/year ÷ 24.465 tons-VOC/year
= $[redacted]/ton-VOC (with Recovery Credits)

The analysis demonstrates that the annualized purchase cost of the refrigerated condenser system and annual costs alone results in a cost effectiveness which exceeds the District's Guideline of $17,500/ton-VOC. Therefore this option is not cost-effective and will not be considered for this project.

Collection of VOCs and control by absorption (> 81% collection & control)

Design Basis

- The District provided notice to Andrew Fedak of NohBell Corporation to allow NohBell Corporation an opportunity to provide cost information. The District did not receive updated cost information; therefore, the NohBell equipment_pricing and capital investment requirements developed for District Project N-1131615 (Gallo Livingston) will be factored as required to develop a cost effectiveness analysis for this project.
- Although the NoMoVo units have not been demonstrated at the scale of operation as proposed by this project, the District will conservatively assume that the proposed equipment and equipment cost proposed by NohBell will meet the duty requirements for the project.
- The District will consider the average control efficiency of the unit to be 81% for purposes of this project, consistent with the District's BACT Guideline for this class and category.
- The EPA Control Cost Manual, Sixth Edition (EPA/452/B-02-001) is used for this analysis with modifications to account for project-specific conditions.
- Instrumentation allowance of $2,000 per NoMoVo unit has been included for a pressure transmitter and a temperature transmitter for monitoring pressure of the collection header and vent stream and temperature from the NoMoVo unit.
- Sales tax = 3%
- Foundations and supports: not required – unit is supported from either a tank or the pipe rack structure. Equipment price includes required attachments and clips.
- Since the units are mobile which are ready for operation upon delivery, Handling and Erection is taken to be 2% of Purchased Equipment Cost as an allowance for pre-commissioning.
- Piping is taken to be 1% of Purchased Equipment Cost based on the only requirements being Tee fittings for the tank discharge.
- Gallo has indicated that, consistent with their current plant and corporate operating philosophy, programable logic controls and data logging as well as integration with existing digital control systems will be required for any fermentation control system installed. The district has added an allowance of $10,000 per unit to cover the expected hardware and programming cost of this item.
- Insulation and painting are not required.
- Recovered ethanol storage tank = $40,000 (installed)
- Due to the unsteady state operation of fermentation tanks, initial source testing is expected to be a significant technical operation with significant expense, conducted over the fermentation cycle rather than the typical three 30-minute steady state measurements. An additional cost of $15,000 per unit will be assumed for initial source testing.
- Engineering costs will be assumed to be 5% of total direct cost exclusive of city/county plan check costs. The District believes that this value reflects a typical minimum for any significant industrial project and believes that this is consistent with standard estimating and good engineering practice.
- An allowance of $10,000 will be added to cover plan check and building permit fees.
- Owner's Cost: The District considers a value of $100,000 as a minimum value to cover the project management, internal engineering and operations planning required to implement a significant new process technology of this scale in a commercial winery.

- Project Contingency: Good engineering practice and accepted norms of the engineering industry, when applied to an conceptual estimate of this type, require a project contingency exceeding 20%. Contingencies less than 10% are only achieved when preliminary engineering has been completed (all major equipment fully specified and firm quotations received, approved piping and instrumentation diagrams, plot plans and equipment layouts) plus a preliminary design basis and/or preliminary design sketches with material take-off for all significant cost components of the project. Contingencies less than 5% are only applicable to projects for which all engineering is completed and approved for construction. Based on this discussion, the District will apply a conservative project contingency of 20% to the estimated capital investment for this project.
- Operating labor is estimated based on 2 operator hours per day per operating unit over a 90 day crush season and an hourly cost of $18.50 per hour.
- An allowance for annual maintenance cost was included as 1% of Total Capital Investment.
- Connected electrical load for each unit is 2.5 horsepower which is assumed to operate continuously for 90 days.
- Electric power cost = $0.102/kWh (see regenerative thermal oxidizer Top Down BACT Analysis section below)
- Captured ethanol is recovered as a 10% solution suitable for disposal to an ethanol distillery at a cost of $0.08 per gallon.
- Annual source testing will be required. It is assumed that only one representative unit will require testing each year. An annual charge of $15,000 has been included.

Equipment Cost Scrubber

Pricing for the NoMoVo units will be based on pricing previously received from NohBell Corporation for District Project N-1131615.

In project N-1131615, NohBell Corporation sized 18 scrubbers to handle twenty-four (24) 56,000 gallon tanks (total volume of 1,344,000 gallons) with a combined flow rate of 6,926.4 scfm (288.6 scfm x 24 tanks) and a combined VOC emission rate of 84,864 lb-VOC/year (3,536 lb-VOC/year x 24 tanks). Each tank in this project has a capacity of 350,000 gallons, a flow rate of 1,803.9 scfm, and an emission rate of 5,034 lb-VOC/year. Therefore, using the equipment cost of 18 scrubbers sized for the operation in project N-1131615 would be conservative as those scrubbers would be undersized to handle the tanks in this project. As a conservative assumption, for this BACT analysis 18 scrubbers will serve the 12 fermentation tanks.

As quoted by NohBell, based on supply of 18 NoMoVo units each sized to control twenty-four (24) 56,000-gallon tanks, the price per scrubber is shown below.

NoMoVo v4.0-18 Reactor Units = $60,000 each
NoMoVo v2.0 Portable Pumping Skids = $7,500 each
Total = $60,000 + $7,500 = $67,500

Total Equipment Cost = $67,500 x 18 units
= $1,215,000

Scrubber	
Cost Description	Cost ($)
Refrigerated Scrubber System (18 NoVoMo Units)	$1,215,000
The following cost data is taken from EPA Control Cost Manual, Sixth Edition (EPA/452/B-02-001).	
Direct Costs (DC)	
Base Equipment Costs (Scrubber System) See Above	$1,215,000
Instrumentation ($2,000 per unit)	$40,000
Sales Tax 3%	$36,450
Freight (included)	-
Purchased equipment cost	**$1,291,450**
Foundations & supports (not required)	-
Handling & erection 2%	$25,829
Electrical 1%	$12,915
Piping 1%	$12,915
Painting (not required)	-
Insulation (not required)	-
PLC & Programming	$180,000
Recovered Ethanol Storage Tank (installed)	$40,000
Direct installation costs	**$271,659**
Total Direct Costs (TDC)	**$1,563,109**
Indirect Costs (IC)	
Engineering (5% of TDC)	$78,155
Construction and field expenses (2% of TDC)	$31,262
Permits (Building Department) (Allowance)	$10,000
Contractor fees (2% of TDC)	$31,262
Start-up (1% of TDC)	$15,631
Source Testing (18 units x $15,000/unit)	$270,000
Owner's Cost (Allowance)	$100,000
Total Indirect Costs (TIC)	**$536,310**
Subtotal Capital Investment (SCI = TDC + TIC)	**$2,099,419**
Project Contingency (20% of SCI)	$419,884
Total Capital Investment (TCI) (TDC + TIC + Contingency)	**$2,519,303**

Annualized Capital Costs

Annualized Capital Investment = Initial Capital Investment x Amortization Factor

Amortization Factor = $\left[\frac{0.1(1.1)^{10}}{(1.1)^{10}-1}\right]$ = 0.1627, amortizing over 10 years at 10%

Therefore,

Annualized Capital Investment = $2,519,303 x 0.1627 = $410,005

Wastewater Disposal Costs

Additionally, the water scrubber will generate ethanol-laden wastewater containing 30.2 tons-ethanol annually (60,408 lb/year (uncontrolled fermentation emissions) x 0.81 ÷ 2000). Assuming a 10% solution, approximately 91,251 gallons of waste water (30.2 ton-ethanol x 2000 lb/ton x gal/6.62 lb ÷ 0.10) will be generated annually. Per NohBell Corporation, an allowance of $0.08 per gallon is applied for disposal costs.

Annual disposal costs = 91,251 gallons x $0.08/gallon = $7,300

Annual Costs

Annual Costs			
Direct Annual Cost (DC)			
Operating Labor			
Operator	2 hr/day x 18 units x 90 days = 3,240 hr/year	$18.50/h	$59,940
Supervisor	15% of operator		$8,991
Maintenance			
Labor	1% of TCI		$26,065
Wastewater Disposal			
	10% Solution = 91,251 gal	$0.08/gal	$7,300
Utility			
Electricity	18 units x 2.5 hp x 0.746 kW/hp x 2,160 hr/yr = 72,511 kWh/yr	$0.102/kWh	$7,396
Total DC			**$109,692**
Indirect Annual Cost (IC)			
Overhead	60% of Labor Cost	0.6 x ($59,940 + $8,991 + $26,065)	$56,998
Administrative	2% TCI		$52,129
Property Taxes	1% TCI		$26,065
Insurance	1% TCI		$26,065
Annual Source Test	One representative test/year @ $15,000		$15,000
Total IC			**$176,257**
Annual Cost (DC + IC)			**$285,949**

Total Annual Cost = Scrubber System + Annual Cost
= $410,005 + $285,949
= $695,954

Emission Reductions

The District's BACT Guideline identifies an overall collection and control efficiency of 81% for absorption systems.

Annual Emission Reduction = Fermentation Emissions x 0.81
= 60,408 lb-VOC/year x 0.81
= 48,930 lb-VOC/year
= 24.5 tons-VOC/year

Cost Effectiveness

Cost Effectiveness = Total Annual Cost ÷ Annual Emission Reductions

Cost Effectiveness = $695,954/year ÷ 24.5 tons-VOC/year
= $28,446/ton-VOC

The analysis demonstrates that the annualized purchase cost of the water scrubber and annual costs alone results in a cost effectiveness which exceeds the District's Guideline of $17,500/ton-VOC. Therefore this option is not cost-effective and will not be considered for this project.

Collection of VOCs and control by carbon adsorption (> 86% collection and control)

Collection System Capital Investment (based on ductwork)

A potential common feature of all thermal or catalytic oxidation/carbon adsorption options when configured as a large single control device controlling many tanks is that they require installation of a collection system for delivering the VOCs from the tanks to the common control device. Therefore, the requirements and cost of such a collection system will be considered separately.

Collection system to consist of:

- The collection system consists of stainless steel place ductwork (stainless steel is required due to food grade product status) with isolation valving, connecting twelve tanks to a common manifold system which ducts the combined vent to the common control device. The cost of dampers and isolation valving, installed in the ductwork, will be included in the cost estimate.
- A minimum duct size is established at six inches diameter at each tank to provide adequate strength for spanning between supports. The main header is twelve inches diameter to handle the potential for simultaneous venting. The main header duct size of twelve inches may be insufficient for red wine fermentation but will be utilized as a worst case scenario.

Capital Cost Ductwork

Connection from tank to main duct = 12 tanks x 702 feet x $144/foot = $101,088
Main duct for fermenters = $145,056
Redundant main duct for fermenters = $246,144
Unit installed cost for 6 inch butterfly valve = $2,125/valve x 12 valves x 2 systems = $51,000
Unit installed cost one foot removable spool = $500/tank x 12 tanks x 2 systems = $12,000
Knockout drums = $46,300
Duct support allowance = $150,000

Total = $101,088 + $145,056 + $246,144 + $51,000 + $12,000 + $46,300 + $150,000
= $751,588

Instrumentation and electrical (grounding and dampers) may be required but will be excluded as a worst case scenario (based on comments provided by the emission control device vendors).

Ductwork	
Cost Description	Cost ($)
Duct Estimate (See Duct Sizing Attachment A)	$751,588
Adjusting factor from 2005 dollars to 2014 dollars (2.75% inflation/year)	1.2475
Inflation adjusted duct cost	$937,606
The following cost data is taken from EPA Control Cost Manual, Sixth Edition (EPA/452/B-02-001).	
Direct Costs (DC)	
Base Equipment Costs (Ductwork) See Above	$937,606
Instrumentation (not required)	-
Sales Tax 3%	$28,128
Freight 5%	$46,880
Purchased equipment cost	**$1,012,614**
Foundations & supports 8%	$81,009
Handling & erection 14%	$141,766
Electrical 4% (not required)	-
Piping 2% (not required)	-
Painting 1% (not required)	-
Insulation 1% (not required)	-
Direct installation costs	**$222,775**
Total Direct Costs	**$1,235,389**
Indirect Costs (IC)	
Engineering 10%	$101,261
Construction and field expenses 5%	$50,631
Contractor fees 10%	$101,261
Start-up 2%	$20,252
Performance test 1%	$10,126
Contingencies 3%	$30,378
Total Indirect Costs	**$313,909**
Total Capital Investment (TCI) (DC + IC)	**$1,549,298**

Capital Cost Clean-In-Place (CIP) System

A ducting system on a tank farm must have this system to maintain sanitation and quality of the product. The cost of operation of the CIP system has not been estimated. Operation of a CIP system, using typical cleaning agents, will raise disposal and wastewater treatment costs. Most likely, these costs will be significant.

Clean-In-Place (CIP) System	
Cost Description	Cost ($)
Current cost of CIP system	$200,000
The following cost data is taken from EPA Control Cost Manual, Sixth Edition (EPA/452/B-02-001).	
Direct Costs (DC)	
Base Equipment Costs (CIP System) See Above	$200,000
Instrumentation 10%	$20,000
Sales Tax 3%	$6,000
Freight 5%	$10,000
Purchased equipment cost	**$236,000**
Foundations & supports 8%	$18,880
Handling & erection 14%	$33,040
Electrical 4%	$9,440
Piping 2%	$4,720
Painting 1%	$2,360
Insulation 1%	$2,360
Direct installation costs	**$70,800**
Total Direct Costs	**$306,800**
Indirect Costs (IC)	
Engineering 10%	$23,600
Construction and field expenses 5%	$11,800
Contractor fees 10%	$23,600
Start-up 2%	$4,720
Performance test 1%	$2,360
Contingencies 3%	$7,080
Total Indirect Costs	**$73,160**
Total Capital Investment (TCI) (DC + IC)	**$379,960**

Annualized Capital Costs

Two CIP systems are required for a redundant ducting system.

Total capital costs = Ductwork + CIP System (x 2)
= $1,563,977 + $379,960 + $379,960
= $2,323,897

Annualized Capital Investment = Initial Capital Investment x Amortization Factor

Amortization Factor = $\left[\frac{0.1(1.1)^{10}}{(1.1)^{10}-1}\right]$ = 0.163 per District policy, amortizing over 10 years at 10%

Therefore,

Annualized Capital Investment = $2,323,897 x 0.163 = $378,204

Carbon Adsorption

Delivery and installation of a 1,000 cfm blower package for carbon adsorption is $80,000 - $85,000 and delivery and installation of a 50 cfm blower package for carbon adsorption is $20,000 - $25,000 per David Drewelow of Drewelow Remediation Equipment on February 3, 2015. The combined vapor flow rate for the tanks in this project is 21,649 cfm. A value of $80,000 for the 1,000 cfm blower package will be used as a conservative estimate.

Carbon Adsorption Capital Cost = $80,000

The carbon bed operated with steam to regenerate the bed produces a water alcohol mixture. The applicant has provide a cost of $5,000 for a water alcohol tank. The waste stream or disposal costs have not been analyzed in this project.

Carbon Capital Cost

Annual Emission Reduction = Fermentation Emissions x 0.86
= 60,408 lb-VOC/year x 0.86
= 51,951 lb-VOC/year
= 26.0 tons-VOC/year

Assume a working bed capacity of 20% for carbon (weight of vapor per weight of carbon)

Carbon required = 26.0 tons-VOC/year x 2000 lb/ton x 1/0.20
= 259,754 lb carbon

David Drewelow also provided a cost of $1.25/lb of carbon which does not include any delivery or servicing fees.

Carbon capital cost = $1.25/lb = $1.25/lb x 259,754 lb carbon = $324,693

Carbon Adsorption	
Cost Description	Cost ($)
Carbon Adsorption cost (see above)	$80,000
Carbon Capital Cost (see above)	$324,693
Water alcohol tank cost	$5,000
The following cost data is taken from EPA Control Cost Manual, Sixth Edition (EPA/452/B-02-001).	
Direct Costs (DC)	
Base Equipment Costs (Carbon Adsorption System + Carbon) See Above	$409,693
Instrumentation 10%	$40,969
Sales Tax 3%	$12,291
Freight 5%	$20,485
Purchased equipment cost	**$483,438**
Foundations & supports 8%	$38,675
Handling & erection 14%	$67,681
Electrical 4%	$19,338
Piping 2%	$9,669
Painting 1%	$4,834
Insulation 1%	$4,834
Direct installation costs	**$145,031**
Total Direct Costs	**$628,469**
Indirect Costs (IC)	
Engineering 10%	$48,344
Construction and field expenses 5%	$24,172
Contractor fees 10%	$48,344
Start-up 2%	$9,669
Performance test 1%	$4,834
Contingencies 3%	$14,503
Total Indirect Costs	**$149,866**
Total Capital Investment (TCI) (DC + IC)	**$778,335**

Annualized Capital Costs

Annualized Capital Investment = Initial Capital Investment x Amortization Factor

Amortization Factor = $\left[\frac{0.1(1.1)^{10}}{(1.1)^{10}-1}\right]$ = 0.163 per District policy, amortizing over 10 years at 10%

Therefore,

Annualized Capital Investment = $778,335 x 0.163 = $126,670

Total Annual Cost

Total Annual Cost = Carbon Adsorption System + Ductwork + CIP System
= $126,670 + $378,204
= $504,874

Emission Reductions

Annual Emission Reduction = Fermentation Emissions x 0.86
= 60,408 lb-VOC/year x 0.86
= 51,951 lb-VOC/year
= 26.0 tons-VOC/year

Cost Effectiveness

Cost Effectiveness = Total Annual Cost ÷ Annual Emission Reductions

Cost Effectiveness = $504,874/year ÷ 26.0 tons-VOC/year
= $19,437/ton-VOC

The analysis demonstrates that the annualized purchase cost of the carbon adsorption system and collection system ductwork and CIP equipment alone results in a cost effectiveness which exceeds the District's Guideline of $17,500/ton-VOC. Therefore this option is not cost-effective and will not be considered for this project.

Collection of VOCs and control by thermal or catalytic oxidation
(> 88% collection & control)

The balanced chemical equation for combustion of ethanol is shown below.

$C_2H_5OH + 3O_2 \rightarrow 3H_2O + 2CO_2$

The RTO would be connected by ducts to the tanks themselves. If the tanks were to overfill and send liquid down the duct, damage to the RTO could occur. The presence of significant liquid in the knock out drum would cause a shut down of the RTO until the issue could be corrected. The ducting costs include a knock out drum allowance.

Thermal or Catalytic Oxidizer Capital Cost

A total capital investment cost of $290,000 and installation cost including freight of $42,000 for a Regenerative Thermal Oxidizer (RTO) is provided by Adwest Technologies, Inc on September 24, 2014 for an RTO handling 10,000 scfm. Therefore, this cost estimate will be used in this project as a conservative estimate

Capital Cost = $290,000 + $42,000
= $332,000

Thermal or Catalytic Oxidation	
Cost Description	Cost ($)
1,000 cfm Regenerative Thermal Oxidizer cost	$290,000
Installation cost (including freight)	$42,000
The following cost data is taken from EPA Control Cost Manual, Sixth Edition (EPA/452/B-02-001).	
Direct Costs (DC)	
Base Equipment Costs (Regenerative Thermal Oxidizer System) See Above	$332,000
Instrumentation 10%	$33,200
Sales Tax 3%	$9,960
Freight 5% (included)	-
Purchased equipment cost	**$375,160**
Foundations & supports 8%	$30,013
Handling & erection 14%	$52,522
Electrical 4%	$15,006
Piping 2%	$7,503
Painting 1%	$3,752
Insulation 1%	$3,752
Direct installation costs	**$112,548**
Total Direct Costs	**$487,708**

Indirect Costs (IC)	
Engineering 10%	$37,516
Construction and field expenses 5%	$18,758
Contractor fees 10%	$37,516
Start-up 2%	$7,503
Performance test 1%	$3,752
Contingencies 3%	$11,255
Total Indirect Costs	**$116,300**
Total Capital Investment (TCI) (DC + IC)	**$604,008**

Annualized Capital Costs

Annualized Capital Investment = Initial Capital Investment x Amortization Factor

Amortization Factor = $\left[\frac{0.1(1.1)^{10}}{(1.1)^{10}-1}\right]$ = 0.163 per District policy, amortizing over 10 years at 10%

Therefore,

Annualized Capital Investment = $604,008 x 0.163 = $98,300

Operation and Maintenance Costs

The Direct annual costs include labor (operating, supervisory, and maintenance), maintenance materials, electricity, and fuel.

Heat of Combustion for waste gas stream -dh(c):

heat of combustion -dHc	= 20,276 Btu/lb
Daily VOC emissions rate	= 1,211.0 lb/day x 12 tanks = 14,532.0 lb/day
Blower flow rate	= 21,647 scfm
	= 31,171,680 ft^3/day

-dh(c) = 14,532.0 lb/day x 20,276 Btu/lb ÷ 31,171,680 ft^3/day
= 9.45 Btu/ft^3

Assuming the waste gas is principally air, with a molecular weight of 28.97 and a corresponding density of 0.0739 lb/scf, the heat of combustion per pound of incoming waste gas is:

-dh(c) = 9.45 Btu/ft^3 ÷ 0.0739 lb/ft^3
= 127.91 Btu/lb

Fuel Flow Requirement

$$Q(fuel) = \frac{Pw*Qw*\{Cp*[1.1Tf-Tw-0.1Tr]-[-dh(c)]\}}{P(ef) * [-dh(m) - 1.1\ Cp * (Tf - Tr)]}$$

Where

Pw	=	0.0739 lb/ft^3
Cp	=	0.255 Btu/lb-°F
Qw	=	21,647 scfm
-dh(m)	=	21,502 Btu/lb for methane
Tr	=	77°F assume ambient conditions
P(ef)	=	0.0408 lb/ft^3, methane at 77°F, 1 atm
Tf	=	1600°F
Tw	=	1150°F
-dh(c)	=	127.91 Btu/lb

$$Q = \frac{0.0739*21{,}647*\{0.255*[1.1*1{,}600-1{,}150-0.1*77]-127.91\}}{0.0408*[21{,}502 - 1.1*0.255*(1{,}600 - 77)]}$$

$$= 41{,}075.73 \div 859.9 = 47.77\ ft^3/min$$

Fuel Costs

The cost for natural gas shall be based upon the average price of natural gas sold to "Commercial Consumers" in California for the years 2011 and 2012.[1]

2012	= \$8.28/thousand ft^3 total monthly average
2011	= \$7.13/thousand ft^3 total monthly average
Average for two years	= \$7.705/thousand ft^3 total monthly average

Fuel Cost = 47.77 cfm x 1440 min/day x 365 day/year x \$7.705/1000 ft^3
= \$193,449/year

Electricity Requirement

$$Power_{fan} = \frac{1.17*10^{-4}\ Qw*\ \Delta P}{\epsilon}$$

Where

ΔP	=	Pressure drop Across system = 4 in. H_2O
ϵ	=	Efficiency for fan and motor = 0.6
Qw	=	21,647 scfm

[1] Energy Information Administration/Natural Gas; Average Price of Natural Gas Sold to Commercial Consumers by State, 2011 - 2012

$$\text{Power}_{fan} = \frac{1.17*10^{-4} *21{,}647 \text{ cfm}* 4 \text{ in. } H_2O}{0.60}$$
$$= 16.88 \text{ kW}$$

Electricity Costs

Average cost of electricity to commercial users in California [2]:
2012 = $0.1023
2011 = $0.1012
AVG = $0.102

Electricity Cost = 16.88 kW x 24 hours/day x 365 days/year x $0.102/kWh = $15,087/year

Total Utility Costs

Annual Cost (Data from: Annual Costs for Thermal and Catalytic Incinerators, Table 3.10 – OAQPS Control Cost Manual, Fourth Edition)

Annual Cost			
Operator	0.5 h/shift	$18.5/h x 0.5 h x 365 days/yr	$3,376
Supervisor	15% of operator		$506
Maintenance			
Labor	0.5 h/shift	$18.5/h x 0.5 h x 365 days/yr	$3,376
Material	100% of labor		$3,376
Utility			
Natural Gas			$193,449
Electricity			$15,087
Indirect Annual Cost (IC)			
Overhead	60% of Labor Cost	0.6 x ($3,376 + $506 + $3,376)	$4,355
Administrative Charge	2% TCI		$29,451
Property Taxes	1% TCI		$14,725
Insurance	1% TCI		$14,725
Total Annual Cost			**$282,426**

Total Annual Cost

Total Annual Cost = Regenerative Thermal Oxidizer System + Ductwork + CIP System + Annual Cost
= $98,300 + $378,204 + $282,426
= $758,930

2 Energy Information Administration/Electric Power; Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State, 2011 - 2012

Emission Reductions

Annual Emission Reduction = Fermentation Emissions x 0.88
= 60,408 lb-VOC/year x 0.88
= 53,159 lb-VOC/year
= 26.6 tons-VOC/year

Cost Effectiveness

Cost Effectiveness = Total Annual Cost ÷ Annual Emission Reductions

Cost Effectiveness = $758,930/year ÷ 26.6 tons-VOC/year
= $28,553/ton-VOC

The analysis demonstrates that the annualized purchase cost of the regenerative thermal oxidizer system, collection system ductwork and CIP equipment, and annual costs alone results in a cost effectiveness which exceeds the District's Guideline of $17,500/ton-VOC. Therefore this option is not cost-effective and will not be considered for this project.

Step 5 – Select BACT

All identified feasible options with control efficiencies higher than the option proposed by the facility have been shown to not be cost effective. The facility has proposed Option 1, temperature-controlled open top tank with maximum average fermentation temperature of 95 deg F. These BACT requirements will be placed on the permits as enforceable conditions.