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 N-1237-670-0 through '693-0

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 2 and is as follows:

1) Temperature-Controlled Open Top Tank with Maximum Average Fermentation Temperature of 95 deg F

The SJVUAPCD BACT Clearinghouse guideline 5.4.14, 3rd quarter 2013, 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.

General Basis and Assumptions

- The proposed new tanks in this project consist of groups of tank sizes ranging from 6,500 gallon capacity each up to 210,000 gallons each. This BACT analysis will be first performed based on considering only the largest 210,000 gallon tanks (N-96-360-0 to '-363-0). If it is shown that a particular technology is not cost effective for the largest tanks, it is then assumed that it will not be cost effective for the smaller tanks (since the potential emissions are linear with tank size and there will be a loss of economy of scale for smaller sizes).

- Annual uncontrolled fermentation PE for permit units N-96-360-0 to '-363-0 is 11,979 lb/year per Appendix C.

- Maximum CO2 flow rate from each tank is 483 cfm at 60 F per a proprietary model provided by E & J Gallo based on a white wine fermentation at 60 F and an initial sugar concentration of 20 °Brix.

- It is assumed all 4 fermentation tanks can reach maximum flow simultaneously. The design rate for the capture and control system is therefore 4 x 483 = 1,932 cfm.

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

Basis and Assumptions: Evaluation of this option is based on the EcoPAS technology which is the only condensation technology known to the District which is both commercially available and which has been developed specifically for control of emissions from wine fermentation tanks. Pricing for the refrigerated condenser option was obtained from EcoPAS under District project N-1131615. In that project, EcoPAS submitted a budgetary estimate to control 24 red wine fermentation tanks using four proprietary PAS control units. Each PAS unit was dedicated to a bay of six fermentation tanks. The units operate based on a small backpressure on the tanks and do not require induced draft fans. Chilled glycol/water is supplied from the winery central facility for condensing the ethanol vapor. The four units proposed for that project did not have sufficient capacity to actually control all 24 tanks under a scenario where all tanks reached maximum fermentation rate at the same time. Instead, the design relied upon variability of operation in the tanks as well as planned staging of the fermentation operations to ensure that the capacity of control devices would not be exceeded during operation.

- <u>As a conservative assumption, for purposes of the analysis</u>, it will be assumed that the EcoPAS design for project N-1131615, relying upon variability of operation in the tanks as well as planned staging of the fermentation operations to ensure that the capacity of control devices will not be exceeded during operation, is valid and workable.
- 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.
- The EcoPAS 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
- To develop a Purchased Equipment Cost (PEC) for each project, the Base PEC from N-1131615 will be considered the Base Estimate and the PEC for this project ("New") will be developed by factoring the Base PEC by the ratio of project capacity with an exponent of 0.6 $[(Capacity_{new}/Capacity_{base})^{0.6}]$ where "Capacity" refers to the adjusted total nominal volume of all tanks included in the analysis (commonly referred to the "6-tenths Rule", traditionally employed to extrapolate equipment costs from one capacity to a different capacity) .
- Since the tanks in this project are white fermenters versus the red fermenter considered in base project N-1131615, the capacity of white fermentation tanks must be adjusted to an equivalent red fermenter flow basis in order to recognize 1) that the peak flow from white fermentation is substantially less than that of red fermentation per gallon of fermenting must and 2) that the maximum percentage fill of the tank for white fermentation is greater than that for red fermentation (more gallons of must will be in the tank when conducting a white fermentation).
- Peak CO_2 flow for red fermentation is 43.5 lb-CO_2/hour per 1000 gallons of fermenting must as calculated by the Gallo kinetic model and based on an 80F fermentation with starting sugar = 20 °Brix
- Peak CO_2 flow for white fermentation is 15.9 lb-CO_2/hour per 1000 gallons of fermenting must as calculated by the Gallo kinetic model and based on an 60F fermentation with starting sugar = 20 °Brix
- Peak flow from a white fermenter is therefore 15.9/43.5 = 36.2% of that from a red fermenter per 1000 gallons of fermenting must.
- Maximum percentage fill of a red fermenter is 80% versus 95% for a white fermenter. Therefore, the maximum gallons of must fermenting in a white fermentation tank of a given size is 95%/80% = 119% of the maximum gallons of red must.

- The unadjusted capacity for this analysis is based on four 210,000 gallon white fermentation tanks = 4 x 210,000 = 840,000 gallons. Adjusting this value to an equivalent red fermenter yields:

  Adjusted Capacity = 840,000 gallons x 36.2% x 119% = 361,855 gallons

- The parameters of the current evaluation are compared with the Base Project in the following table:

Summary of Comparative Parameters		
Project Number	**N-1131615**	**N-1133555**
Facility	**Gallo (Base Project)**	**Bear Creek**
Fermentation Type	Red	White
No of Tanks	24	4
Individual Tank Capacity gallons	56,000	210,000
Project Capacity gallons	1,344,000	840,000
Adjusted project Capacity, gallons	1,344,000	361,855

- The quoted capture and control efficiency of the EcoPAS system has been stated to be 90% based on limited small-scale pilot testing. Given that the unit operation has not been fully demonstrated at this time, the District will consider the average control efficiency of the unit to be only 81% for purposes of this project, consistent with the District's BACT Guideline for this class and category source.
- Controlled emissions are calculated as:

  11,970 x 81%/2,000 = 4.8 tons

- The Base Project included $10,000 in direct cost for each EcoPAS unit as an allowance for PLC control and data logging which was a site specific requirement for that facility. The applicant for this project has not indicated this to be a requirement at this time and therefore it will be conservatively assumed that the PLC cost is not applicable to this project.
- In the Base Project, EcoPAS provided site-specific installation costs for the proposed scope of supply. The installation costs from that analysis will be factored by the ratio of adjusted project capacity to establish installation costs for this project.
- Engineering costs will be assumed to be 5% of total direct cost exclusive of city/county plan check costs.

- An allowance of 10,000 is included to cover all permitting costs including County planning and building department costs.
- 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. A cost of $15,000 will be assumed for initial source testing.
- Owner's costs are included at 6% of Total Direct Cost up to a maximum of $100,000.
- Project contingency is included at 20% of Total Capital Investment based on good engineering practice and accepted estimating norms of the engineering industry.
- Operating labor is estimated based on 1 operator hour per shift and 3 shifts per day, 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.
- Recovered ethanol is estimated at approximately 4,882 gallons per year based on 60 proof (11,970 lb/year (uncontrolled fermentation emissions) x 81% x gal/6.62 lb ÷ 0.30). The recovered 60 proof is conservatively assumed to have a value of $25 per gallon based on statements by EcoPAS.

- 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%

Annualized Capital Investment = Initial Capital Investment x 0.163

Total Capital Investment for Refrigerated Condenser:

Total Capital Investment is presented in the following table along with the estimate from the Base Project:

Total Capital Investment		
TCI - Direct Costs (DC)	**N-1131615**	**N-1133555**
Purchased equipment cost (inc frgt & sales tax)	$1,901,272	$865,218
PLC, Data, Software	$40,000	N/A
Foundations & supports (not required)	-	
Handling & erection	$140,775	$37,902
Electrical (not required)	-	
Piping (not included)		
Painting (not required)	-	
Insulation (not required)	-	
Subcontracts	$18,000	$4,846
Direct installation costs	**$198,775**	**$42,748**
Total Direct Costs	**$2,100,047**	**$907,966**
TCI - Indirect Costs (IC)		
Engineering	$105,002	$45,398
Plan check/Building Permits	$10,000	$10,000
Initial Source Testing	$60,000	$15,000
Owner's Cost	$100,000	$54,478
Total Indirect Costs	**$275,002**	**$124,876**
Subtotal Cap Inv	**$2,375,049**	**$1,032,842**
Owner's Contingency 20%	$475,010	$206,568
Total Capital Investment (TCI) (DC + IC)	**$2,850,059**	**$1,239,411**

Total Annual Cost and Cost Effectiveness

The Total Annual Cost, including the recovered ethanol credit is presented in the following table along with the cost effectiveness calculation. As indicated in the table, the evaluated cost effectiveness 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.

Total Annual Cost & Cost Effectiveness		
Direct Costs	**N-1131615**	**N-1133555**
Operator (2 hours/unit/day, 90 days, $18.50/hour)	$19,980	$3,330
Supervisor (15% of Operator)	$1,998	$500
Maintenance		
Labor (1% of TIC)	$28,501	$12,394
Utility		
Chiller (Glycol) - $270/ton recovered ethanol	$9,280	$328
Electricity (none required)	$0	$0
Total DC	**$59,759**	**$16,552**
Indirect Annual Cost (IC)		
Overhead (60% of labor and maintenance)	$30,287.16	$9,734
Annual Source test	$15,000	$15,000
Administrative Charge (2% TCI)	$57,001	$24,788
Property Taxes (1% TCI)	$28,501	$12,394
Insurance (1% TCI)	$28,501	$12,394
Total IC	$159,290	$74,311
Recovery Credits (RC)		
60 Proof Recovered	$70,349	$122,050
Annual Cost (DC + IC – RC)	**$148,699**	**-$31,187**
Annualized TCI (0.163 x TCI)	$463,705	$201,652
Total Annual Costs	$612,404	$170,465
Tons Control	34.370	4.8
CE $ per ton	**$17,818**	**$35,514**
Cost Effective?	**NO**	**NO**

<u>Collection of VOCs and control by absorption (≥ 81% collection & control)</u>

<u>Basis and Assumptions:</u> Evaluation of this option is based on the NoMoVo technology (NohBell Corporation) which is the only absorption technology (refrigerated water scrubber) known to the District which is both commercially available and which has been developed specifically for control of emissions from wine fermentation tanks. Pricing for the refrigerated water scrubber was obtained from NohBell Corporation under District project N-1131615. In that project, NohBell submitted a budgetary estimate to control 24 red wine fermentation tanks using eighteen proprietary NoMoVo control units. Each NoMoVo unit was dedicated to a single tank although NohBell has stated that a single unit may control more than one unit at a time and that the 18 units would be capable of controlling all 24 tanks considering variability of operation in the tanks as well as planned staging of the fermentation operations to ensure that the capacity of control devices would not be exceeded during operation. The units operate based on a small backpressure on the tanks and do not require induced draft fans. Chilled glycol/water is supplied from a chiller/pump package supplied with each control unit.

- <u>As a conservative assumption, for purposes of the analysis</u>, it will be assumed that the NohBell design for project N-1131615, relying upon variability of operation in the tanks as well as planned staging of the fermentation operations to ensure that the capacity of control devices will not be exceeded during operation, is valid and workable.
- 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
- To develop a Purchased Equipment Cost (PEC) for each project, the Base PEC from N-1131615 will be considered the Base Estimate and the PEC for this project ("New") will be developed by factoring the Base PEC by the ratio of project capacity with an exponent of 0.6 $[(Capacity_{new}/Capacity_{base})^{0.6}]$ where "Capacity" refers to the adjusted total nominal volume of all tanks included in the analysis (commonly referred to the "6-tenths Rule", traditionally employed to extrapolate equipment costs from one capacity to a different capacity) .
- Since the tanks in this project are white fermenters versus the red fermenter considered in base project N-1131615, the capacity of white fermentation tanks must be adjusted to an equivalent red fermenter flow basis in order to recognize 1) that the peak flow from white fermentation is substantially less than that of red fermentation per gallon of fermenting must and 2) that the maximum percentage fill of the tank for white fermentation is greater than that for red fermentation (more gallons of must will be in the tank when conducting a white fermentation).
- Peak CO_2 flow for red fermentation is 43.5 lb-CO_2/hour per 1000 gallons of fermenting must as calculated by the Gallo kinetic model and based on an 80F fermentation with starting sugar = 20 °Brix
- Peak CO_2 flow for white fermentation is 15.9 lb-CO_2/hour per 1000 gallons of fermenting must as calculated by the Gallo kinetic model and based on an 60F fermentation with starting sugar = 20 °Brix

- Peak flow from a white fermenter is therefore 15.9/43.5 = 36.2% of that from a red fermenter per 1000 gallons of fermenting must.
- Maximum percentage fill of a red fermenter is 80% versus 95% for a white fermenter. Therefore, the maximum gallons of must fermenting in a white fermentation tank of a given size is 95%/80% = 119% of the maximum gallons of red must.
- The unadjusted capacity for this analysis is based on four 210,000 gallon white fermentation tanks = 4 x 210,000 = 840,000 gallons. Adjusting this value to an equivalent red fermenter yields:

  Adjusted Capacity = 840,000 gallons x 36.2% x 119% = 361,855 gallons

- The parameters of the current evaluation are compared with the Base Project in the following table:

Summary of Comparative Parameters		
Project Number	**N-1131615**	**N-1133555**
Facility	**Gallo (Base Project)**	**Bear Creek**
Fermentation Type	Red	White
No of Tanks	24	4
Individual Tank Capacity gallons	56,000	210,000
Project Capacity gallons	1,344,000	840,000
Adjusted project Capacity, gallons	1,344,000	361,855

- The quoted average capture and control efficiency of the NohBell system has been stated to be 81% which is consistent with the District's BACT Guideline for this class and category source.
- Controlled emissions are calculated as:

  11,970 x 81%/2,000 = 4.8 tons

- The Base Project included $10,000 in direct cost for each NohBell unit as an allowance for PLC control and data logging which was a site specific requirement for that facility. The applicant for this project has not indicated this to be a requirement at this time and therefore it will be conservatively assumed that the PLC cost is not applicable to this project.
- In the Base Project, technology-specific installation cost factors were established and formed the basis of that estimate. The installation costs from that analysis will be factored by the ratio of adjusted project capacity to establish installation costs for this project:

- 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 = 8.225% based on California location
- 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.
- Insulation and painting are not required.

- Installed cost for a 20,000 gallon waste ethanol solution storage tank is included in the estimate. Total direct cost for installation of a 22,000 gallon tank is estimated based on 2003 costs published by the State of Michigan, UIP 11[1] for welded steel water tanks. UIP 11 indicates an installed cost 0f $30,000 (2003 dollars). The total direct cost of the tank includes typical tank ancillaries such as roof, ladders, painting, fittings on tank, etc., plus the tank foundation. Escalating this cost to 2014 at 2.75% per year, the current direct cost of the tank is determined to be $40,400.
- Engineering costs will be assumed to be 5% of total direct cost exclusive of city/county plan check costs.
- An allowance of 10,000 is included to cover all permitting costs including County planning and building department costs.
- 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. A cost of $15,000 will be assumed for initial source testing.
- Owner's costs are included at 6% of Total Direct Cost up to a maximum of $100,000.
- Project contingency is included at 20% of Total Capital Investment based on good engineering practice and accepted estimating norms of the engineering industry. .
- Operating labor is estimated based on 2 operator hours per unit per day, operating units over a 90 day crush season and an hourly cost of $18.50 per hour. For purposes of the estimate, a total of 5 NoMoVo units are assumed to be required.
- An allowance for annual maintenance cost was included as 1% of Total Capital Investment.
- Connected electrical load for each NoMoVo 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.

- Annualized Capital Investment = Total Capital Investment x Amortization Factor

[1] State of Michigan, UIP 11, Tanks, www.michigan.gov/documents/Vol2-35UIP11Tanks_121080_7.pdf, . 2003. S4

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

Annualized Capital Investment = Initial Capital Investment x 0.163

Total Annual Cost and Cost Effectiveness

The Total Annual Cost, including the recovered ethanol credit is presented in the following table along with the cost effectiveness calculation. As indicated in the table, the evaluated cost effectiveness 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.

Total Annual Cost & Cost Effectiveness		
Project Number	**N-1131615 (Gallo- Base Project)**	**N-1133555 (Bear Creek)**
Direct Costs		
Operator ($18.50/hr, 2 hours/unit/day, 90 days)	$66,600	$16,650
Supervisor (15% of Operator)	$10,490	$2,498
Maintenance		
Labor (1% of TIC)	$23,065	$9,789
Wastewater Disposal		
10% solution, $0.08 per gallon	$8,307	$1,172
Utility		
Chiller (Glycol) - none required		
Electricity 2.5 hp/unit, 2160 hr/yr, 0.102/kWh	$7,393	$2,054
Total DC	**$115,855**	**$32,163**
Indirect Annual Cost (IC)		
Overhead (60% of labor and maintenance)	$60,092.72	$17,362
Annual Source test	$15,000	15000
Administrative Charge (2% TCI)	$46,129	$19,577
Property Taxes (1% TCI)	$23,065	$9,789
Insurance (1% TCI)	$23,065	$9,789
Total IC	$167,351	$71,517
Recovery Credits (RC)		
60 Proof Recovered	$0	$0
Annual Cost (DC + IC – RC)	**$283,205**	**$103,680**
Annualized TCI x 0.163	$375,260	$159,556
Total Annual Costs	$658,465	$263,236
Tons Control	34.370	4.800
CE $ per ton	**$19,158**	**$54,840**
Cost Effective?	**NO**	**NO**

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

The proposed new tanks consist of groups of tank sizes ranging from 6,500 gallon capacity each up to 210,000 gallons each. This BACT analysis will be first performed based on considering only the 210,000 gallon tanks. If it is shown that carbon adsorption is not cost effective for these tanks, it will be assumed that it will not be cost effective for the smaller tanks (since the potential emissions are linear with tank size and there will be a loss of economy of scale for smaller sizes).

Basis and Assumptions

- Annual uncontrolled fermentation PE for permit units N-96-360-0 to '-363-0 is 11,970 lb/year per Appendix C.
- Since this facility is not equipped with a boiler for regeneration of activated carbon, the analysis will be based on using 2000 lb non-regenerable fixed-bed absorbers (canisters).
- The carbon adsorption system (CAS) is assumed to consist of a 2-row array of non-regenerable absorbers with each row of absorbers containing sufficient carbon to adsorb the maximum daily PE of the four fermentation tanks.
- Maximum CO2 flow rate from each tank is 483 cfm at 60 F per a proprietary model provided by E & J Gallo based on a white wine fermentation at 60 F and an initial sugar concentration of 20 °Brix.
- It is assumed all 4 fermentation tanks can reach maximum flow simultaneously. The design rate for the CAS and its supply duct is therefore 4 x 483 = 1,932 cfm.
- The CAS is assumed to be located at grade, approximately 25 feet from the nearest tank. The 4 fermentation tanks are 30' diameter and 40' tall each and are arranged in a square array per the applicant's plot plan. Based on this, duct branch connections to each tank are estimated at 25 feet long and the main header is determined to be a minimum of 100 feet long.
- Maximum duct velocity is limited to 40 feet per second to minimize pressure on the tanks. Based on this criterion, the duct connection to each tank is determined to be 6" diameter and the main header is determined to be 12" diameter.
- The collection system consists of stainless steel plate ductwork (stainless steel is required due to food grade product status) with isolation valving connecting the four proposed 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.

- Direct cost of ductwork is taken from the Eichleay Study.[2] The following pricing is applicable to ductwork and includes labor and materials (pricing is estimated to be approximately 50% labor, 50% materials):

- 6" ductwork: $61.50 per linear foot
- 12" ductwork: $144 per linear foot
- Allowance for duct supports: $4,000 per tank
- Isolation valves $2,125 each

- Pricing of the CAS is based on the EPA Air Pollution Control Cost Manual (APCCM).[3]

- Carbon utilization is assumed to be 20%.

- Maximum daily emissions from each fermentation tank are 1.62 lb-VOC per 1000 gallons of tank capacity per District's FYI-114. Total daily emissions to the CAS are therefore 4 x 210,000 x 1.62/1000 = 1,361 lb-VOC/day.

- At a carbon utilization of 20%, the minimum amount of carbon in each adsorber row is 1,361/20% = 6,804 lb. Therefore each row will consist of four non-regenerable adsorbers, or a total of eight adsorbers in the array.

- Purchase cost of a 2000 lb carbon adsorber vessel is $2,500 per David Drewelow of Drewelow Remediation Equipment.

- Delivery and installation of a 1,000 cfm blower package for carbon adsorption is $80-85,000 and delivery and installation of a 50cfm blower package for carbon adsorption is $20-25,000 per David Drewelow of Drewelow Remediation Equipment. Assuming $80,000 and $20,000 respectively for the above-mentioned systems, extrapolating for a 1,932 cfm system, yields $138,863.

- Capital investment will be evaluated based only on ductwork. Other costs which are recognized but not included in this evaluation are 1) knock out drum, fan and vent stack for the CAS, 2) piping, instrumentation, electrical and all other direct and indirect costs associated with the CAS and 3) Clean-in-Place (CIP) system for sanitizing the ductwork

[2] Eichleay Engineers, Fermenter VOC Emissions Control Cost Estimate, 2005.

[3] U.S.EPA Air Pollution Control Cost Manual, Section 3, Chapter 1, Carbon Absorbers.

- Evaluation of annual operating costs will be based only on the supply and installation of non-regenerable carbon beds. Other costs which are recognized but not included in this evaluation are 1) operating labor and maintenance, 2) disposal costs for the spent carbon and 3) all other direct and indirect costs associated with operation of the CAS.

Capital Investment Required Based on Ductwork Only

Direct Costs			
	Qty	Unit Direct Cost	Direct Cost Extension
6" ductwork	100	$61.50	$6,150
12" ductwork	100	$144.00	$14,400
Tank Isolation Valves	4	$2,125.00	$8,500
Duct Supports	4	$4,000.00	$16,000
Subtotal Direct Cost (2005 dollars)			$45,050
Escalation at 2.75%			$12,458
Carbon Adsorption Equipment			$138,863
Subtotal Direct Cost			$196,371
Sales Tax 3.3125%[4]			$6,505
Total Direct Cost (DC)			$202,876
Indirect Costs			
Engineering 10% of DC			$20,288
Construction and field expenses 5% DC			$10,144
Contractor fees 10% DC			$20,288
Start-up 2% DC			$4,058
Contingency 10% DC			$20,288
Total Indirect Costs (IC)			$75,066
Total Capital Investment for Ductwork (DC+IC)			**$277,942**

Total Capital Investment for Carbon Adsorber Equipment = $277,942

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,

[4] Pollution control equipment is qualify for CA tax partial exemption, and the exemption rate is 4.1875%, so the reduced sales tax rate is equal 3.3125% (7.500% - 4.1875%). http://www.boe.ca.gov/sutax/manufacturing_exemptions.htm#Purchasers

Annualized Capital Investment = $277,942 x 0.163 = $45,305 per year

Annual Operating Cost Based on Carbon Purchase Only

VOC adsorbed annually = 86% x 11,970 = 10,294 lb-VOC/year

Annual carbon requirement at 20% carbon utilization = 10,294/20% = 51,470 lb-Carbon/year

Number of carbon adsorbers per year = 51,470/2,000 = 26 carbon absorbers/year

Annual purchase cost for adsorbers = 26 x $2,500 = $65,000

Total Annual Cost = Annualized Capital Investment + Annual Operating Cost

Total Annual Cost = $45,305 + $65,000 = $110,305

Uncontrolled fermentation PE for proposed ATCs N-96-360-0 to '-363-0 is 11,970 lb-VOC/year.

Annual Emission Reduction = Uncontrolled Emissions x 0.86
= 11,970 lb-VOC/year x 0.86
= 10,294 lb-VOC/year
= 5.1 tons-VOC/year

Cost Effectiveness

Cost Effectiveness = Total Annual Cost ÷ Annual Emission Reductions

Cost Effectiveness = $110,305/year ÷ 5.1 tons-VOC/year
= $21,628/ton-VOC

The analysis demonstrates that the annualized cost based only on the capital investment for ductwork plus the annual carbon absorber replacement cost 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 proposed new tanks consist of groups of tank sizes ranging from 6,500 gallon capacity each up to 210,000 gallons each. This BACT analysis will be first performed based on considering only the 210,000 gallon tanks. If it is shown that thermal oxidation is not cost effective for these tanks, it will be assumed that it will not be cost effective for the smaller tanks (since the potential emissions are linear with tank size and there will be a loss of economy of scale for smaller sizes).

Basis and Assumptions

- Annual uncontrolled fermentation PE for permit units N-96-360-0 to '-363-0 is 11,970 lb/year per Appendix C.

- The thermal oxidizer is assumed to be a regenerative thermal oxidizer (RTO) with 95% fuel efficiency.

- Maximum CO2 flow rate from each tank is 483 cfm at 60 F per a proprietary model provided by E & J Gallo based on a white wine fermentation at 60 F and an initial sugar concentration of 20 °Brix.

- It is assumed all 4 fermentation tanks can reach maximum flow simultaneously. The design rate for the RTO and its supply duct is therefore 4 x 483 = 1,932 cfm.

- The RTO is assumed to be located at grade, approximately 25 feet from the nearest tank. The 4 fermentation tanks are 30' diameter and 40' tall each and are arranged in a square array per the applicant's plot plan. Based on this, duct branch connections to each tank are estimated at 25 feet long and the main header is determined to be a minimum of 100 feet long.

- Maximum duct velocity is limited to 40 feet per second to minimize pressure on the tanks. Based on this criterion, the duct connection to each tank is determined to be 6" diameter and the main header is determined to be 12" diameter.

- The collection system consists of stainless steel plate ductwork (stainless steel is required due to food grade product status) with isolation valving connecting the four proposed 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.

- Direct unit costs of ductwork are taken from the Eichleay Study.[5] The following pricing is applicable to ductwork and includes labor and materials (pricing is estimated to be approximately 50% labor, 50% materials):

6" ductwork:	$61.50 per linear foot
12" ductwork:	$144 per linear foot
Allowance for duct supports:	$4,000 per tank
Isolation valves	$2,125 each

[5] Eichleay Engineers, Fermenter VOC Emissions Control Cost Estimate, 2005.

- Pricing of the RTO is based on pricing obtain from Adwest Technologies in September of 2014. Considering that the costs are nearly linear between the different sized units, based on the costs provided, the price of a 1,930 cfm RTO is estimated at $161,820.

- Capital investment will be evaluated based only on the RTO and ductwork. Other costs which are recognized but not included in this evaluation are 1) knock out drum to prevent wine reaching the RTO, 2) Clean-in-Place (CIP) system for sanitizing the ductwork and 3) site specific costs for utilities (natural gas and electric power).

- Annual Operating Costs are presented per the cost model given by the EPA Air Pollution Control Cost Manual (APCCM).[6] Some of the cost factors have been modified to reflect good engineering practice and/or local conditions.

- Natural gas consumption will be based on a 95% efficient RTO operating for 90 days. No credit for the fuel value of ethanol is considered since the ethanol rate will tend to be highly variable, occurring primarily in spikes during fermentation peak operating points.

- Unit price of natural gas is $7.71/MMBtu[7].

- Electric power consumption is computed for the RTO fan based on the maximum CO2 vent rate from the tanks plus a 50% allowance for combustion air. Assumed parameters for the fan are 10" water column differential pressure, 60% static efficiency, 90% electric motor efficiency, 90 days full time operation.

- Electricity cost is $.102/kWh.[8]

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[6] U.S.EPA Air Pollution Control Cost Manual, Section 3.2, Chapter 2, Incinerators.
[7] Energy Information Administration/Natural Gas; Average Price of Natural Gas Sold to Commercial Consumers by State, 2011 - 2013
[8] Energy Information Administration/Electric Power; Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State, 2011 - 2012

Capital Investment Required Based on Ductwork Only

Direct Costs			
	Qty	Unit Direct Cost	Direct Cost Extension
6" ductwork	100	$61.50	$6,150
12" ductwork	100	$144.00	$14,400
Tank Isolation Valves	4	$2,125.00	$8,500
Duct Supports	4	$4,000.00	$16,000
Subtotal Direct Cost (2005 dollars)			$45,050
Escalation at 2.75%			$12,458
Total Direct Cost (DC)			$57,508
Indirect Costs			
Engineering 10% of DC			$5,751
Construction and field expenses 5% DC			$2,875
Contractor fees 10% DC			$5,751
Start-up 2% DC			$901
Contingency 10% DC			$5,751
Total Indirect Costs (IC)			$21,029
Total Capital Investment for Ductwork (DC+IC)			**$78,537**

Capital Investment for the RTO

Total Capital Investment for Thermal Oxidizer		
Direct Costs		
Purchased Equipment Costs		
Oxidizer (A)		$161,820
Instrumentation 10% A		$16,182
Sales Tax 3.8125% (8.0% - 4.1875%[9]) A		$6,776
Freight 5% A		Including in DI Cost
Purchased Equipment Cost (PEC)		$184,778
Direct Installation Costs Provided by Adwest Technologies, Inc		
Direct Installation Cost Including Freight		$33,840
Total Direct Cost DC		$218,618
Indirect Costs		
Engineering 10% DC		$21,862
Construction and Field Expense 5% DC		$10,931
Contractor Fees 10% DC		$21,862
Startup 2% DC		$4,372
Performance Test 1% DC		$2,186
Contingency 10% DC		$21,862
Total Indirect Cost IC		$111,456
Total Capital Investment DC + IC		**$301,700**

Total Capital Investment Including Ductwork

The Total Capital Investment (TCI) for this option is the sum of that for the RTO plus that for the ductwork:

TCI = $301,700 + 78,537 = ≈380,200

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%

[9] Manufacturing and Research & Development Exemption. http://www.boe.ca.gov/sutax/manufacturing_exemptions.htm

Therefore,

Annualized Capital Investment = \$380,200 x 0.163 = \$61,973 per year

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	= 340.2 lb/day
Blower flow rate	= 1,932 scfm
	= 2,782,080 ft^3/day

$$-dh(c) = 340.2 \text{ lb/day} \times 20{,}276 \text{ Btu/lb} / 2{,}782{,}080 \text{ ft}^3\text{/day} = 2.479 \text{ Btu/ft}^3$$

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:

$$-dh(c) = 2.479 \text{ Btu/ft}^3 / 0.0739 \text{ lb/ft}^3 = 33.55 \text{ Btu/lb}$$

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	=	1,932 scfm
-dh(m)	=	21,502 Btu/lb for methane
Tr	=	77°F assume ambient conditions
P(ef)	=	0.0408 lb/ft^3 m, methane at 77°F, 1 atm
Tf	=	1600°F
Tw	=	1150°F
-dh(c)	=	33.55 Btu/lb

$$Q = \frac{0.0739*1{,}932*\{0.255*[1.1*1{,}600-1{,}150-0.1*77]-33.55\}}{0.0408*[21{,}502 - 1.1*0.255*(1{,}600 - 77)]}$$

$$= 17{,}138 \div 860 = 19.93 \text{ ft}^3\text{/min}$$

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, 2012 and 2013.[10]

2013	= \$7.81/thousand ft^3 total monthly average
2012	= \$8.29/thousand ft^3 total monthly average
2011	= \$7.05/thousand ft^3 total monthly average
Average for two years	= \$7.717/thousand ft^3 total monthly average

Fuel Cost = 19.93 cfm x 1440 min/day x 90 day/year x \$7.717/1000 ft^3
= \$19,932/year

Electricity Requirement

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

Where

ΔP = Pressure drop Across system = 10 in. H_2O

ϵ = Efficiency for fan and motor = 0.6

Qw = 6,200 scfm

$$\text{Power}_{\text{fan}} = \frac{1.17 * 10^{-4} * 1{,}932\ \text{cfm} * 1.5 * 10\ \text{in. } H_2O}{0.60 * 0.90}$$

$$= 6.28\ \text{kW}$$

Electricity Costs

Average cost of electricity to commercial users in California [11]:

2012 = \$0.1023
2011 = \$0.1012
AVG = \$0.102

Electricity Cost = 6.28 kW x 24 hours/day x 90 days/year x \$0.102/kWh = \$1,384/year

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

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

Annual Costs

Annual Costs for Thermal Oxidizer		
Direct Annual Costs		
Operating Labor		
Operator (.5 hr/shift)		$2,498
Supervisor (15% of operator)		$375
Maintenance (1% TCI)		$3,802
Utilities		
Natural Gas		$19,932
Electricity		$1,384
Total Direct Cost DC		$27,991
Indirect Annual Costs		
Overhead (60% of labor and maintenance)		$4,005
Administrative charges (2% TCI)		$7,604
Property Taxes (1% TCI)		$3,802
Insurance (1% TCI)		$3,802
Capital Recovery (CRF x TCI)		$61,973
Total Indirect Cost IC		$81,186
Total Annual Cost (DC + IC)		**$109,177**

Cost Effectiveness

Cost Effectiveness = Total Annual Cost ÷ Annual Emission Reductions

Uncontrolled fermentation PE for proposed ATCs N-96-360-0 to '-363-0 is 11,970 lb-VOC/year per Appendix C.

Annual Emission Reduction = Uncontrolled Emissions x 0.70
= 11,970 lb-VOC/year x 0.95
= 11,370 lb-VOC/year
= 5.7 tons-VOC/year

Cost Effectiveness = $109,177/year ÷ 5.7 tons-VOC/year
= $19,154/ton-VOC

The analysis demonstrates that the annualized cost (without consideration of requirements for a knock out drum, CIP system or site-specific cost) 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.